



Database Compatibility for Oracle® Developer's Guide

EDB Postgres™ Advanced Server 10

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Database Compatibility for Oracle® Developer's Guide
by EnterpriseDB® Corporation
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Table of Contents

1	Introduction	9
1.1	What's New	10
1.2	Typographical Conventions Used in this Guide	10
1.3	Configuration Parameters Compatible with Oracle Databases	11
1.3.1	edb_redwood_date	12
1.3.2	edb_redwood_raw_names	12
1.3.3	edb_redwood_strings	13
1.3.4	edb_stmt_level_tx	15
1.3.5	oracle_home	16
1.4	About the Examples Used in this Guide	17
2	SQL Tutorial	18
2.1	Getting Started	18
2.1.1	Sample Database	19
2.1.1.1	Sample Database Installation	19
2.1.1.2	Sample Database Description	19
2.1.2	Creating a New Table	30
2.1.3	Populating a Table With Rows	31
2.1.4	Querying a Table	32
2.1.5	Joins Between Tables	34
2.1.6	Aggregate Functions	38
2.1.7	Updates	40
2.1.8	Deletions	41
2.1.9	The SQL Language	42
2.2	Advanced Concepts	43
2.2.1	Views	43
2.2.2	Foreign Keys	45
2.2.3	The ROWNUM Pseudo-Column	46
2.2.4	Synonyms	48
2.2.5	Hierarchical Queries	50
2.2.5.1	Defining the Parent/Child Relationship	51
2.2.5.2	Selecting the Root Nodes	51
2.2.5.3	Organization Tree in the Sample Application	51
2.2.5.4	Node Level	53
2.2.5.5	Ordering the Siblings	54
2.2.5.6	Retrieving the Root Node with CONNECT_BY_ROOT	55
2.2.5.7	Retrieving a Path with SYS_CONNECT_BY_PATH	59
2.2.6	Multidimensional Analysis	61
2.2.6.1	ROLLUP Extension	63
2.2.6.2	CUBE Extension	66
2.2.6.3	GROUPING SETS Extension	70
2.2.6.4	GROUPING Function	76
2.2.6.5	GROUPING_ID Function	79
2.3	Profile Management	82
2.3.1	Creating a New Profile	83
2.3.1.1	Creating a Password Function	86
2.3.2	Altering a Profile	89
2.3.3	Dropping a Profile	90
2.3.4	Associating a Profile with an Existing Role	91
2.3.5	Unlocking a Locked Account	93
2.3.6	Creating a New Role Associated with a Profile	95
2.3.7	Backing up Profile Management Functions	97
2.4	Optimizer Hints	98

2.4.1	Default Optimization Modes	100
2.4.2	Access Method Hints	102
2.4.3	Specifying a Join Order	106
2.4.4	Joining Relations Hints	107
2.4.5	Global Hints.....	110
2.4.6	Using the APPEND Optimizer Hint.....	113
2.4.7	Parallelism Hints	114
2.4.8	Conflicting Hints	119
3	Stored Procedure Language.....	120
3.1	Basic SPL Elements	120
3.1.1	Character Set.....	120
3.1.2	Case Sensitivity	121
3.1.3	Identifiers	121
3.1.4	Qualifiers	121
3.1.5	Constants.....	122
3.1.6	User-Defined PL/SQL Subtypes	123
3.2	SPL Programs	126
3.2.1	SPL Block Structure.....	127
3.2.2	Anonymous Blocks	129
3.2.3	Procedures Overview	130
3.2.3.1	Creating a Procedure	130
3.2.3.2	Calling a Procedure.....	134
3.2.3.3	Deleting a Procedure	135
3.2.4	Functions Overview	136
3.2.4.1	Creating a Function.....	136
3.2.4.2	Calling a Function.....	141
3.2.4.3	Deleting a Function	142
3.2.5	Procedure and Function Parameters	143
3.2.5.1	Positional vs. Named Parameter Notation.....	144
3.2.5.2	Parameter Modes	146
3.2.5.3	Using Default Values in Parameters	148
3.2.6	Subprograms – Subprocedures and Subfunctions.....	149
3.2.6.1	Creating a Subprocedure	150
3.2.6.2	Creating a Subfunction	152
3.2.6.3	Block Relationships	154
3.2.6.4	Invoking Subprograms	156
3.2.6.5	Using Forward Declarations	163
3.2.6.6	Overloading Subprograms	164
3.2.6.7	Accessing Subprogram Variables	168
3.2.7	Compilation Errors in Procedures and Functions	175
3.2.8	Program Security	177
3.2.8.1	EXECUTE Privilege	177
3.2.8.2	Database Object Name Resolution	178
3.2.8.3	Database Object Privileges	179
3.2.8.4	Definer's vs. Invokers Rights	179
3.2.8.5	Security Example.....	180
3.3	Variabl e Declarations	187
3.3.1	Declaring a Variabl e	187
3.3.2	Using %TYPE in Variable Declarations	189
3.3.3	Using %ROWTYPE in Record Declarations	192
3.3.4	User-Defined Record Types and Record Variables	193
3.4	Basic Statements	196
3.4.1	NULL	196
3.4.2	Assignment	196
3.4.3	SELECT INTO	197
3.4.4	INSERT	199

3.4.5	UPDATE	201
3.4.6	DELETE	201
3.4.7	Using the RETURNING INTO Clause	202
3.4.8	Obtaining the Result Status	205
3.5	Control Structures	206
3.5.1	IF Statement	206
3.5.1.1	IF-THEN	206
3.5.1.2	IF-THEN-ELSE	207
3.5.1.3	IF-THEN-ELSE IF	208
3.5.1.4	IF-THEN-ELSIF-ELSE	209
3.5.2	RETURN Statement	211
3.5.3	GOTO Statement	212
3.5.4	CASE Expression	214
3.5.4.1	Selector CASE Expression	214
3.5.4.2	Searched CASE Expression	215
3.5.5	CASE Statement	217
3.5.5.1	Selector CASE Statement	217
3.5.5.2	Searched CASE statement	218
3.5.6	Loops	221
3.5.6.1	LOOP	221
3.5.6.2	EXIT	221
3.5.6.3	CONTINUE	222
3.5.6.4	WHILE	222
3.5.6.5	FOR (integer variant)	223
3.5.7	Exception Handling	225
3.5.8	User-defined Exceptions	227
3.5.9	PRAGMA EXCEPTION_INIT	229
3.5.10	RAISE_APPLICATION_ERROR	231
3.6	Transaction Control	233
3.6.1	COMMIT	234
3.6.2	ROLLBACK	235
3.7	Dynamic SQL	239
3.8	Static Cursors	242
3.8.1	Declaring a Cursor	242
3.8.2	Opening a Cursor	242
3.8.3	Fetching Rows From a Cursor	243
3.8.4	Closing a Cursor	244
3.8.5	Using %ROWTYPE With Cursors	246
3.8.6	Cursor Attributes	247
3.8.6.1	%ISOPEN	247
3.8.6.2	%FOUND	247
3.8.6.3	%NOTFOUND	248
3.8.6.4	%ROWCOUNT	250
3.8.6.5	Summary of Cursor States and Attributes	251
3.8.7	Cursor FOR Loop	251
3.8.8	Parameterized Cursors	252
3.9	REF CURSORS and Cursor Variables	254
3.9.1	REF CURSOR Overview	254
3.9.2	Declaring a Cursor Variable	254
3.9.2.1	Declaring a SYS_REFCURSOR Cursor Variable	254
3.9.2.2	Declaring a User Defined REF CURSOR Type Variable	255
3.9.3	Opening a Cursor Variable	255
3.9.4	Fetching Rows From a Cursor Variable	256
3.9.5	Closing a Cursor Variable	256
3.9.6	Usage Restrictions	257
3.9.7	Examples	258

3.9.7.1	Returning a REF CURSOR From a Function	258
3.9.7.2	Modularizing Cursor Operations	259
3.9.8	Dynamic Queries With REF CURSORS	261
3.10	Collections	264
3.10.1	Associative Arrays	264
3.10.2	Nested Tables	268
3.10.3	Varrays	272
3.11	Collection Methods	275
3.11.1	COUNT	275
3.11.2	DELETE	275
3.11.3	EXISTS	277
3.11.4	EXTEND	277
3.11.5	FIRST	280
3.11.6	LAST	280
3.11.7	LIMIT	281
3.11.8	NEXT	281
3.11.9	PRIOR	282
3.11.10	TRIM	282
3.12	Working with Collections	284
3.12.1	TABLE()	284
3.12.2	Using the MULTISET UNION Operator	284
3.12.3	Using the FORALL Statement	286
3.12.4	Using the BULK COLLECT Clause	288
3.12.4.1	SELECT BULK COLLECT	289
3.12.4.2	FETCH BULK COLLECT	290
3.12.4.3	EXECUTE IMMEDIATE BULK COLLECT	292
3.12.4.4	RETURNING BULK COLLECT	292
3.13	Errors and Messages	295
4	Triggers	296
4.1	Overview	296
4.2	Types of Triggers	297
4.3	Creating Triggers	298
4.4	Trigger Variables	301
4.5	Transactions and Exceptions	303
4.6	Trigger Examples	303
4.6.1	Before Statement-Level Trigger	303
4.6.2	After Statement-Level Trigger	304
4.6.3	Before Row-Level Trigger	305
4.6.4	After Row-Level Trigger	305
5	Packages	308
6	Object Types and Objects	309
6.1	Basic Object Concepts	309
6.1.1	Attributes	310
6.1.2	Methods	310
6.1.3	Overloading Methods	310
6.2	Object Type Components	311
6.2.1	Object Type Specification Syntax	311
6.2.2	Object Type Body Syntax	315
6.3	Creating Object Types	318
6.3.1	Member Methods	318
6.3.2	Static Methods	319
6.3.3	Constructor Methods	320
6.4	Creating Object Instances	323
6.5	Referencing an Object	324
6.6	Dropping an Object Type	326
7	Open Client Library	327

8	Oracle Catalog Views	328
9	Tools and Utilities.....	329
10	Table Partitioning	330
10.1	Selecting a Partition Type	331
10.2	Using Partition Pruning	332
10.2.1	Example - Partition Pruning	336
10.3	Partitioning Commands Compatible with Oracle Databases	339
10.3.1	CREATE TABLE...PARTITION BY	339
10.3.1.1	Example - PARTITION BY LIST	343
10.3.1.2	Example - PARTITION BY RANGE	344
10.3.1.3	Example - PARTITION BY HASH	345
10.3.1.4	Example - PARTITION BY RANGE, SUBPARTITION BY LIST	346
10.3.2	ALTER TABLE...ADD PARTITION.....	348
10.3.2.1	Example - Adding a Partition to a LIST Partitioned Table	350
10.3.2.2	Example - Adding a Partition to a RANGE Partitioned Table	351
10.3.3	ALTER TABLE... ADD SUBPARTITION	353
10.3.3.1	Example - Adding a Subpartition to a LIST-RANGE Partitioned Table	354
10.3.3.2	Example - Adding a Subpartition to a RANGE-LIST Partitioned Table	356
10.3.4	ALTER TABLE...SPLIT PARTITION	358
10.3.4.1	Example - Splitting a LIST Partition	360
10.3.4.2	Example - Splitting a RANGE Partition	362
10.3.5	ALTER TABLE...SPLIT SUBPARTITION	365
10.3.5.1	Example - Splitting a LIST Subpartition	367
10.3.5.2	Example - Splitting a RANGE Subpartition	369
10.3.6	ALTER TABLE... EXCHANGE PARTITION.....	373
10.3.6.1	Example - Exchanging a Table for a Partition	374
10.3.7	ALTER TABLE... MOVE PARTITION	378
10.3.7.1	Example - Moving a Partition to a Different Tablespace	379
10.3.8	ALTER TABLE... RENAME PARTITION	381
10.3.8.1	Example - Renaming a Partition	382
10.3.9	DROP TABLE	383
10.3.10	ALTER TABLE... DROP PARTITION	384
10.3.10.1	Example - Deleting a Partition	384
10.3.11	ALTER TABLE... DROP SUBPARTITION	386
10.3.11.1	Example - Deleting a Subpartition	386
10.3.12	TRUNCATE TABLE	388
10.3.12.1	Example - Emptying a Table	388
10.3.13	ALTER TABLE... TRUNCATE PARTITION	391
10.3.13.1	Example - Emptying a Partition	391
10.3.14	ALTER TABLE... TRUNCATE SUBPARTITION	394
10.3.14.1	Example - Emptying a Subpartition	394
10.4	Handling Stray Values in a LIST or RANGE Partitioned Table	397
10.5	Specifying Multiple Partitioning Keys in a RANGE Partitioned Table	403
10.6	Retrieving Information about a Partitioned Table	404
10.6.1	Table Partitioning Views - Reference	405
10.6.1.1	ALL_PART_TABLES	405
10.6.1.2	ALL_TAB_PARTITIONS	406
10.6.1.3	ALL_TAB_SUBPARTITIONS	407
10.6.1.4	ALL_PART_KEY_COLUMNS	408
10.6.1.5	ALL_SUBPART_KEY_COLUMNS	408
11	ECPGPlus	409
12	dblink_ora	410
12.1	dblink_ora Functions and Procedures	411
12.1.1	dblink_ora_connect()	411
12.1.2	dblink_ora_status()	412
12.1.3	dblink_ora_disconnect()	412

Database Compatibility for Oracle® Developers Guide

12.1.4	dblink_ora_record()	413
12.1.5	dblink_ora_call()	413
12.1.6	dblink_ora_exec()	413
12.1.7	dblink_ora_copy()	414
12.2	Calling dblink_ora Functions	415
13	System Catalog Tables	416
14	Acknowledgements	417

1 Introduction

Database Compatibility for Oracle means that an application runs in an Oracle environment as well as in the EDB Postgres Advanced Server (Advanced Server) environment with minimal or no changes to the application code. Developing an application that is compatible with Oracle databases in the Advanced Server requires special attention to which features are used in the construction of the application. For example, developing a compatible application means choosing compatible:

- System and built-in functions for use in SQL statements and procedural logic.
- Stored Procedure Language (SPL) when creating database server-side application logic for stored procedures, functions, triggers, and packages.
- Data types that are compatible with Oracle databases
- SQL statements that are compatible with Oracle SQL
- System catalog views that are compatible with Oracle's data dictionary

For detailed information about the compatible SQL syntax, data types, and views, please see the *Database Compatibility for Oracle Developers Reference Guide*.

The compatibility offered by the procedures and functions that are part of the Built-in packages is documented in the *Database Compatibility for Oracle Developers Built-in Packages Guide*.

For information about using the compatible tools and utilities (EDB*Plus, EDB*Loader, DRITA, and EDB*Wrap) that are included with an Advanced Server installation, please see the *Database Compatibility for Oracle Developers Tools and Utilities Guide*.

For applications written using the Oracle Call Interface (OCI), EnterpriseDB's Open Client Library (OCL) provides interoperability with these applications. For detailed information about using the Open Client Library, please see the *EDB Postgres Advanced Server OCI Connector Guide*.

Advanced Server contains a rich set of features that enables development of database applications for either PostgreSQL or Oracle. For more information about all of the features of Advanced Server, please consult the user documentation available at the EnterpriseDB website.

Advanced Server documentation is available at:

<http://www.enterprisedb.com/products-services-training/products/documentation>

1.1 What's New

The following database compatibility for Oracle features have been added to Advanced Server 9.6 to create Advanced Server 10:

- Advanced Server now supports a `BIGINT` return value for `SQL%ROWCOUNT`. Previously, an `INTEGER` value was returned. For more information, see Section [3.4.8](#).

1.2 Typographical Conventions Used in this Guide

Certain typographical conventions are used in this manual to clarify the meaning and usage of various commands, statements, programs, examples, etc. This section provides a summary of these conventions.

In the following descriptions a *term* refers to any word or group of words which may be language keywords, user-supplied values, literals, etc. A term's exact meaning depends upon the context in which it is used.

- *Italic font* introduces a new term, typically, in the sentence that defines it for the first time.
- *Fixed-width (mono-spaced) font* is used for terms that must be given literally such as SQL commands, specific table and column names used in the examples, programming language keywords, etc. For example, `SELECT * FROM emp;`
- *Italic fixed-width font* is used for terms for which the user must substitute values in actual usage. For example, `DELETE FROM table_name;`
- A vertical pipe | denotes a choice between the terms on either side of the pipe. A vertical pipe is used to separate two or more alternative terms within square brackets (optional choices) or braces (one mandatory choice).
- Square brackets [] denote that one or none of the enclosed term(s) may be substituted. For example, `[a | b]`, means choose one of "a" or "b" or neither of the two.
- Braces {} denote that exactly one of the enclosed alternatives must be specified. For example, `{ a | b }`, means exactly one of "a" or "b" must be specified.
- Ellipses ... denote that the proceeding term may be repeated. For example, `[a | b] ...` means that you may have the sequence, "b a a b a".

1.3 Configuration Parameters Compatible with Oracle Databases

EDB Postgres Advanced Server supports the development and execution of applications compatible with PostgreSQL and Oracle. Some system behaviors can be altered to act in a more PostgreSQL or in a more Oracle compliant manner; these behaviors are controlled by configuration parameters. Modifying the parameters in the `postgresql.conf` file changes the behavior for all databases in the cluster, while a user or group can SET the parameter value on the command line, effecting only their session. These parameters are:

- `edb_redwood_date` – Controls whether or not a time component is stored in DATE columns. For behavior compatible with Oracle databases, set `edb_redwood_date` to TRUE. See Section [1.3.1](#).
- `edb_redwood_raw_names` – Controls whether database object names appear in uppercase or lowercase letters when viewed from Oracle system catalogs. For behavior compatible with Oracle databases, `edb_redwood_raw_names` is set to its default value of FALSE. To view database object names as they are actually stored in the PostgreSQL system catalogs, set `edb_redwood_raw_names` to TRUE. See Section [1.3.2](#).
- `edb_redwood_strings` – Equates NULL to an empty string for purposes of string concatenation operations. For behavior compatible with Oracle databases, set `edb_redwood_strings` to TRUE. See Section [1.3.3](#).
- `edb_stmt_level_tx` – Isolates automatic rollback of an aborted SQL command to statement level rollback only – the entire, current transaction is not automatically rolled back as is the case for default PostgreSQL behavior. For behavior compatible with Oracle databases, set `edb_stmt_level_tx` to TRUE; however, use only when absolutely necessary. See Section [1.3.4](#).
- `oracle_home` – Point Advanced Server to the correct Oracle installation directory. See Section [1.3.5](#).

1.3.1 `edb_redwood_date`

When `DATE` appears as the data type of a column in the commands, it is translated to `TIMESTAMP` at the time the table definition is stored in the data base if the configuration parameter `edb_redwood_date` is set to `TRUE`. Thus, a time component will also be stored in the column along with the date. This is consistent with Oracle's `DATE` data type.

If `edb_redwood_date` is set to `FALSE` the column's datatype in a `CREATE TABLE` or `ALTER TABLE` command remains as a native PostgreSQL `DATE` data type and is stored as such in the database. The PostgreSQL `DATE` data type stores only the date without a time component in the column.

Regardless of the setting of `edb_redwood_date`, when `DATE` appears as a datatype in any other context such as the data type of a variable in an SPL declaration section, or the data type of a formal parameter in an SPL procedure or SPL function, or the return type of an SPL function, it is always internally translated to a `TIMESTAMP` and thus, can handle a time component if present.

See the *Database Compatibility for Oracle Developers Reference Guide* for more information about date/time data types.

1.3.2 `edb_redwood_raw_names`

When `edb_redwood_raw_names` is set to its default value of `FALSE`, database object names such as table names, column names, trigger names, program names, user names, etc. appear in uppercase letters when viewed from Oracle catalogs (for a complete list of supported catalog views, see the *Database Compatibility for Oracle Developers Reference Guide*). In addition, quotation marks enclose names that were created with enclosing quotation marks.

When `edb_redwood_raw_names` is set to `TRUE`, the database object names are displayed exactly as they are stored in the PostgreSQL system catalogs when viewed from the Oracle catalogs. Thus, names created without enclosing quotation marks appear in lowercase as expected in PostgreSQL. Names created with enclosing quotation marks appear exactly as they were created, but without the quotation marks.

For example, the following user name is created, and then a session is started with that user.

```
CREATE USER reduser IDENTIFIED BY password;
edb=# \c - reduser
Password for user reduser:
You are now connected to database "edb" as user "reduser".
```

When connected to the database as `reduser`, the following tables are created.

```
CREATE TABLE all_lower (col INTEGER);
CREATE TABLE ALL_UPPER (COL INTEGER);
CREATE TABLE "Mixed_Case" ("Col" INTEGER);
```

When viewed from the Oracle catalog, `USER_TABLES`, with `edb_redwood_raw_names` set to the default value `FALSE`, the names appear in uppercase except for the `Mixed_Case` name, which appears as created and also with enclosing quotation marks.

```
edb=> SELECT * FROM USER_TABLES;
schema_name | table_name | tablespace_name | status | temporary
-----+-----+-----+-----+-----+
REDUSER    | ALL_LOWER   |                   | VALID  | N
REDUSER    | ALL_UPPER   |                   | VALID  | N
REDUSER    | "Mixed_Case" |                   | VALID  | N
(3 rows)
```

When viewed with `edb_redwood_raw_names` set to `TRUE`, the names appear in lowercase except for the `Mixed_Case` name, which appears as created, but now without the enclosing quotation marks.

```
edb=> SETedb_redwood_raw_names TO true;
SET
edb=> SELECT * FROM USER_TABLES;
schema_name | table_name | tablespace_name | status | temporary
-----+-----+-----+-----+-----+
reduser    | all_lower   |                   | VALID  | N
reduser    | all_upper   |                   | VALID  | N
reduser    | Mixed_Case  |                   | VALID  | N
(3 rows)
```

These names now match the case when viewed from the PostgreSQL `pg_tables` catalog.

```
edb=> SELECT schemaname, tablename, tableowner FROM pg_tables WHERE
tableowner = 'reduser';
schemaname | tablename | tableowner
-----+-----+-----+
reduser   | all_lower | reduser
reduser   | all_upper | reduser
reduser   | Mixed_Case | reduser
(3 rows)
```

1.3.3 `edb_redwood_strings`

In Oracle, when a string is concatenated with a null variable or null column, the result is the original string; however, in PostgreSQL concatenation of a string with a null variable or null column gives a null result. If the `edb_redwood_strings` parameter is set to `TRUE`, the aforementioned concatenation operation results in the original string as done by Oracle. If `edb_redwood_strings` is set to `FALSE`, the native PostgreSQL behavior is maintained.

The following example illustrates the difference.

The sample application introduced in the next section contains a table of employees. This table has a column named `comm` that is null for most employees. The following query is run with `edb_redwood_string` set to FALSE. The concatenation of a null column with non-empty strings produces a final result of null, so only employees that have a commission appear in the query result. The output line for all other employees is null.

```
SET edb_redwood_strings TO off;

SELECT RPAD(ename,10) || ' ' || TO_CHAR(sal,'99,999.99') || ' ' ||
TO_CHAR(comm,'99,999.99') "EMPLOYEE COMPENSATION" FROM emp;

EMPLOYEE COMPENSATION
-----
ALLEN      1,600.00    300.00
WARD       1,250.00    500.00
MARTIN     1,250.00   1,400.00
TURNER     1,500.00      .00

(14 rows)
```

The following is the same query executed when `edb_redwood_strings` is set to TRUE. Here, the value of a null column is treated as an empty string. The concatenation of an empty string with a non-empty string produces the non-empty string. This result is consistent with the results produced by Oracle for the same query.

```
SET edb_redwood_strings TO on;

SELECT RPAD(ename,10) || ' ' || TO_CHAR(sal,'99,999.99') || ' ' ||
TO_CHAR(comm,'99,999.99') "EMPLOYEE COMPENSATION" FROM emp;

EMPLOYEE COMPENSATION
-----
SMITH      800.00
ALLEN     1,600.00    300.00
WARD       1,250.00    500.00
JONES      2,975.00
MARTIN     1,250.00   1,400.00
BLAKE      2,850.00
CLARK      2,450.00
SCOTT      3,000.00
KING       5,000.00
TURNER     1,500.00      .00
ADAMS      1,100.00
JAMES      950.00
FORD       3,000.00
MILLER     1,300.00
(14 rows)
```

1.3.4 `edb_stmt_level_tx`

In Oracle, when a runtime error occurs in a SQL command, all the updates on the database caused by that single command are rolled back. This is called *statement level transaction isolation*. For example, if a single `UPDATE` command successfully updates five rows, but an attempt to update a sixth row results in an exception, the updates to all six rows made by this `UPDATE` command are rolled back. The effects of prior SQL commands that have not yet been committed or rolled back are pending until a `COMMIT` or `ROLLBACK` command is executed.

In PostgreSQL, if an exception occurs while executing a SQL command, all the updates on the database since the start of the transaction are rolled back. In addition, the transaction is left in an aborted state and either a `COMMIT` or `ROLLBACK` command must be issued before another transaction can be started.

If `edb_stmt_level_tx` is set to `TRUE`, then an exception will not automatically roll back prior uncommitted database updates, emulating the Oracle behavior. If `edb_stmt_level_tx` is set to `FALSE`, then an exception will roll back uncommitted database updates.

Note: Use `edb_stmt_level_tx` set to `TRUE` only when absolutely necessary, as this may cause a negative performance impact.

The following example run in PSQL shows that when `edb_stmt_level_tx` is `FALSE`, the abort of the second `INSERT` command also rolls back the first `INSERT` command. Note that in PSQL, the command `\set AUTOCOMMIT off` must be issued, otherwise every statement commits automatically defeating the purpose of this demonstration of the effect of `edb_stmt_level_tx`.

```
\set AUTOCOMMIT off
SET edb_stmt_level_tx TO off;

INSERT INTO emp (empno,ename,deptno) VALUES (9001, 'JONES', 40);
INSERT INTO emp (empno,ename,deptno) VALUES (9002, 'JONES', 00);
ERROR: insert or update on table "emp" violates foreign key constraint
"emp_ref_dept_fk"
DETAIL: Key (deptno)=(0) is not present in table "dept".

COMMIT;
SELECT empno, ename, deptno FROM emp WHERE empno > 9000;

empno | ename | deptno
-----+-----+-----
(0 rows)
```

In the following example, with `edb_stmt_level_tx` set to `TRUE`, the first `INSERT` command has not been rolled back after the error on the second `INSERT` command. At this point, the first `INSERT` command can either be committed or rolled back.

```
\set AUTOCOMMIT off
```

```

SET edb_stmt_level_tx TO on;

INSERT INTO emp (empno,ename,deptno) VALUES (9001, 'JONES', 40);
INSERT INTO emp (empno,ename,deptno) VALUES (9002, 'JONES', 00);
ERROR: insert or update on table "emp" violates foreign key constraint
"emp_ref_dept_fk"
DETAIL: Key (deptno)=(0) is not present in table "dept".

SELECT empno, ename, deptno FROM emp WHERE empno > 9000;

empno | ename | deptno
-----+-----+-----
 9001 | JONES |      40
(1 row)

COMMIT;

```

A ROLLBACK command could have been issued instead of the COMMIT command in which case the insert of employee number 9001 would have been rolled back as well.

1.3.5 oracle_home

Before creating a link to an Oracle server, you must direct Advanced Server to the correct Oracle home directory. Set the LD_LIBRARY_PATH environment variable on Linux (or PATH on Windows) to the lib directory of the Oracle client installation directory.

For Windows only, you can instead set the value of the oracle_home configuration parameter in the postgresql.conf file. The value specified in the oracle_home configuration parameter will override the Windows PATH environment variable.

The LD_LIBRARY_PATH environment variable on Linux (PATH environment variable or oracle_home configuration parameter on Windows) must be set properly each time you start Advanced Server.

When using a Linux service script to start Advanced Server, be sure LD_LIBRARY_PATH has been set within the service script so it is in effect when the script invokes the pg_ctl utility to start Advanced Server.

For Windows only: To set the oracle_home configuration parameter in the postgresql.conf file, edit the file, adding the following line:

```
oracle_home = 'lib_directory'
```

Substitute the name of the Windows directory that contains oci.dll for lib_directory.

After setting the oracle_home configuration parameter, you must restart the server for the changes to take effect. Restart the server from the Windows Services console.

1.4 About the Examples Used in this Guide

The examples shown in this guide are illustrated using the PSQL program. The prompt that normally appears when using PSQL is omitted in these examples to provide extra clarity for the point being demonstrated.

```
Examples and output from examples are shown in fixed-width, blue font on
a light blue background.
```

Also note the following points:

- During installation of the EDB Postgres Advanced Server the selection for configuration and defaults compatible with Oracle databases must be chosen in order to reproduce the same results as the examples shown in this guide. A default compatible configuration can be verified by issuing the following commands in PSQL and obtaining the same results as shown below.

```
SHOW edb_redwood_date;
edb_redwood_date
-----
on

SHOW datestyle;
DateStyle
-----
Redwood, DMY

SHOW edb_redwood_strings;
edb_redwood_strings
-----
on
```

- The examples use the sample tables, `dept`, `emp`, and `jobhist`, created and loaded when Advanced Server is installed. The `emp` table is installed with triggers that must be disabled in order to reproduce the same results as shown in this guide. Log onto Advanced Server as the `enterprisedb` superuser and disable the triggers by issuing the following command.

```
ALTER TABLE emp DISABLE TRIGGER USER;
```

The triggers on the `emp` table can later be re-activated with the following command.

```
ALTER TABLE emp ENABLE TRIGGER USER;
```

2 SQL Tutorial

This section is an introduction to the SQL language for those new to relational database management systems. Basic operations such as creating, populating, querying, and updating tables are discussed along with examples.

More advanced concepts such as view, foreign keys, and transactions are discussed as well.

2.1 Getting Started

Advanced Server is a *relational database management system* (RDBMS). That means it is a system for managing data stored in *relations*. A relation is essentially a mathematical term for a *table*. The notion of storing data in tables is so commonplace today that it might seem inherently obvious, but there are a number of other ways of organizing databases. Files and directories on Unix-like operating systems form an example of a hierarchical database. A more modern development is the object-oriented database.

Each table is a named collection of *rows*. Each row of a given table has the same set of named *columns*, and each column is of a specific *datatype*. Whereas columns have a fixed order in each row, it is important to remember that SQL does not guarantee the order of the rows within the table in any way (although they can be explicitly sorted for display).

Tables are grouped into *databases*, and a collection of databases managed by a single Advanced Server instance constitutes a database *cluster*.

2.1.1 Sample Database

Throughout this documentation we will be working with a sample database to help explain some basic to advanced level database concepts.

2.1.1.1 Sample Database Installation

When Advanced Server is installed a sample database named, `edb`, is automatically created. This sample database contains the tables and programs used throughout this document.

The tables and programs in the sample database can be re-created at any time by executing the script, `edb-sample.sql`, located in the `samples` subdirectory of the Advanced Server home directory.

This script does the following:

- Creates the sample tables and programs in the currently connected database
- Grants all permissions on the tables to the `PUBLIC` group

The tables and programs will be created in the first schema of the search path in which the current user has permission to create tables and procedures. You can display the search path by issuing the command:

```
SHOW SEARCH_PATH;
```

Altering the search path can be done using commands in PSQL.

2.1.1.2 Sample Database Description

The sample database represents employees in an organization.

It contains three types of records: employees, departments, and historical records of employees.

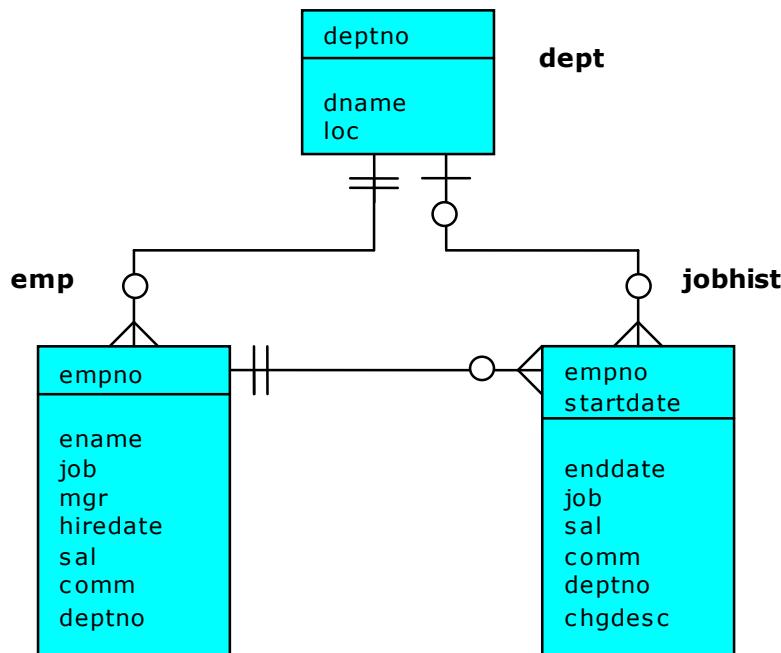
Each employee has an identification number, name, hire date, salary, and manager. Some employees earn a commission in addition to their salary. All employee-related information is stored in the `emp` table.

The sample company is regionally diverse, so the database keeps track of the location of the departments. Each company employee is assigned to a department. Each department is identified by a unique department number and a short name. Each department is associated with one location. All department-related information is stored in the `dept` table.

The company also tracks information about jobs held by the employees. Some employees have been with the company for a long time and have held different positions, received raises, switched departments, etc. When a change in employee status occurs, the company records the end date of the former position. A new job record is added with the start date and the new job title, department, salary, and the reason for the status change. All employee history is maintained in the `jobhist` table.

The following is an entity relationship diagram of the sample database tables.

Figure 1 Sample Database Tables



The following is the `edb-sample.sql` script.

```
--  
-- Script that creates the 'sample' tables, views, procedures,  
-- functions, triggers, etc.  
--  
-- Start new transaction - commit all or nothing  
--  
BEGIN;  
/  
--  
-- Create and load tables used in the documentation examples.  
--  
-- Create the 'dept' table  
--  
CREATE TABLE dept (  
    deptno      NUMBER(2) NOT NULL CONSTRAINT dept_pk PRIMARY KEY,  
    dname       VARCHAR2(14) CONSTRAINT dept_dname_uq UNIQUE,  
    loc         VARCHAR2(13)  
);  
--  
-- Create the 'emp' table  
--  
CREATE TABLE emp (  
    empno       NUMBER(4) NOT NULL CONSTRAINT emp_pk PRIMARY KEY,  
    ename       VARCHAR2(10),  
    job         VARCHAR2(9),  
    mgr         NUMBER(4),  
    hiredate    DATE,  
    sal          NUMBER(7,2) CONSTRAINT emp_sal_ck CHECK (sal > 0),  
    comm        NUMBER(7,2),  
    deptno      NUMBER(2) CONSTRAINT emp_ref_dept_fk  
                REFERENCES dept(deptno)  
);  
--  
-- Create the 'jobhist' table  
--  
CREATE TABLE jobhist (  
    empno       NUMBER(4) NOT NULL,  
    startdate   DATE NOT NULL,  
    enddate     DATE,  
    job         VARCHAR2(9),  
    sal          NUMBER(7,2),  
    comm        NUMBER(7,2),  
    deptno      NUMBER(2),  
    chgdesc     VARCHAR2(80),  
    CONSTRAINT jobhist_pk PRIMARY KEY (empno, startdate),  
    CONSTRAINT jobhist_ref_emp_fk FOREIGN KEY (empno)  
        REFERENCES emp(empno) ON DELETE CASCADE,  
    CONSTRAINT jobhist_ref_dept_fk FOREIGN KEY (deptno)  
        REFERENCES dept (deptno) ON DELETE SET NULL,  
    CONSTRAINT jobhist_date_chk CHECK (startdate <= enddate)  
);  
--  
-- Create the 'salesemp' view  
--  
CREATE OR REPLACE VIEW salesemp AS  
    SELECT empno, ename, hiredate, sal, comm FROM emp WHERE job = 'SALESMAN';  
--  
-- Sequence to generate values for function 'new_empno'.
```

```

--  

CREATE SEQUENCE next_empno START WITH 8000 INCREMENT BY 1;  

--  

-- Issue PUBLIC grants  

--  

GRANT ALL ON emp TO PUBLIC;  

GRANT ALL ON dept TO PUBLIC;  

GRANT ALL ON jobhist TO PUBLIC;  

GRANT ALL ON salesemp TO PUBLIC;  

GRANT ALL ON next_empno TO PUBLIC;  

--  

-- Load the 'dept' table  

--  

INSERT INTO dept VALUES (10,'ACCOUNTING','NEW YORK');  

INSERT INTO dept VALUES (20,'RESEARCH','DALLAS');  

INSERT INTO dept VALUES (30,'SALES','CHICAGO');  

INSERT INTO dept VALUES (40,'OPERATIONS','BOSTON');  

--  

-- Load the 'emp' table  

--  

INSERT INTO emp VALUES (7369,'SMITH','CLERK',7902,'17-DEC-80',800,NULL,20);  

INSERT INTO emp VALUES (7499,'ALLEN','SALESMAN',7698,'20-FEB-  
81',1600,300,30);  

INSERT INTO emp VALUES (7521,'WARD','SALESMAN',7698,'22-FEB-81',1250,500,30);  

INSERT INTO emp VALUES (7566,'JONES','MANAGER',7839,'02-APR-  
81',2975,NULL,20);  

INSERT INTO emp VALUES (7654,'MARTIN','SALESMAN',7698,'28-SEP-  
81',1250,1400,30);  

INSERT INTO emp VALUES (7698,'BLAKE','MANAGER',7839,'01-MAY-  
81',2850,NULL,30);  

INSERT INTO emp VALUES (7782,'CLARK','MANAGER',7839,'09-JUN-  
81',2450,NULL,10);  

INSERT INTO emp VALUES (7788,'SCOTT','ANALYST',7566,'19-APR-  
87',3000,NULL,20);  

INSERT INTO emp VALUES (7839,'KING','PRESIDENT',NULL,'17-NOV-  
81',5000,NULL,10);  

INSERT INTO emp VALUES (7844,'TURNER','SALESMAN',7698,'08-SEP-81',1500,0,30);  

INSERT INTO emp VALUES (7876,'ADAMS','CLERK',7788,'23-MAY-87',1100,NULL,20);  

INSERT INTO emp VALUES (7900,'JAMES','CLERK',7698,'03-DEC-81',950,NULL,30);  

INSERT INTO emp VALUES (7902,'FORD','ANALYST',7566,'03-DEC-81',3000,NULL,20);  

INSERT INTO emp VALUES (7934,'MILLER','CLERK',7782,'23-JAN-82',1300,NULL,10);  

--  

-- Load the 'jobhist' table  

--  

INSERT INTO jobhist VALUES (7369,'17-DEC-80',NULL,'CLERK',800,NULL,20,'New  
Hire');  

INSERT INTO jobhist VALUES (7499,'20-FEB-81',NULL,'SALESMAN',1600,300,30,'New  
Hire');  

INSERT INTO jobhist VALUES (7521,'22-FEB-81',NULL,'SALESMAN',1250,500,30,'New  
Hire');  

INSERT INTO jobhist VALUES (7566,'02-APR-81',NULL,'MANAGER',2975,NULL,20,'New  
Hire');  

INSERT INTO jobhist VALUES (7654,'28-SEP-  
81',NULL,'SALESMAN',1250,1400,30,'New Hire');  

INSERT INTO jobhist VALUES (7698,'01-MAY-81',NULL,'MANAGER',2850,NULL,30,'New  
Hire');  

INSERT INTO jobhist VALUES (7782,'09-JUN-81',NULL,'MANAGER',2450,NULL,10,'New  
Hire');  

INSERT INTO jobhist VALUES (7788,'19-APR-87','12-APR-  
88','CLERK',1000,NULL,20,'New Hire');  

INSERT INTO jobhist VALUES (7788,'13-APR-88','04-MAY-  
89','CLERK',1040,NULL,20,'Raise');
```

```

INSERT INTO jobhist VALUES (7788,'05-MAY-
90',NULL,'ANALYST',3000,NULL,20,'Promoted to Analyst');
INSERT INTO jobhist VALUES (7839,'17-NOV-
81',NULL,'PRESIDENT',5000,NULL,10,'New Hire');
INSERT INTO jobhist VALUES (7844,'08-SEP-81',NULL,'SALESMAN',1500,0,30,'New
Hire');
INSERT INTO jobhist VALUES (7876,'23-MAY-87',NULL,'CLERK',1100,NULL,20,'New
Hire');
INSERT INTO jobhist VALUES (7900,'03-DEC-81','14-JAN-
83','CLERK',950,NULL,10,'New Hire');
INSERT INTO jobhist VALUES (7900,'15-JAN-
83',NULL,'CLERK',950,NULL,30,'Changed to Dept 30');
INSERT INTO jobhist VALUES (7902,'03-DEC-81',NULL,'ANALYST',3000,NULL,20,'New
Hire');
INSERT INTO jobhist VALUES (7934,'23-JAN-82',NULL,'CLERK',1300,NULL,10,'New
Hire');

-- 
-- Populate statistics table and view (pg_statistic/pg_stats)
-- 

ANALYZE dept;
ANALYZE emp;
ANALYZE jobhist;

-- 
-- Procedure that lists all employees' numbers and names
-- from the 'emp' table using a cursor.
-- 

CREATE OR REPLACE PROCEDURE list_emp
IS
    v_empno        NUMBER(4);
    v_ename        VARCHAR2(10);
    CURSOR emp_cur IS
        SELECT empno, ename FROM emp ORDER BY empno;
BEGIN
    OPEN emp_cur;
    DBMS_OUTPUT.PUT_LINE('EMPNO      ENAME');
    DBMS_OUTPUT.PUT_LINE('-----  -----');
    LOOP
        FETCH emp_cur INTO v_empno, v_ename;
        EXIT WHEN emp_cur%NOTFOUND;
        DBMS_OUTPUT.PUT_LINE(v_empno || '      ' || v_ename);
    END LOOP;
    CLOSE emp_cur;
END;
/
-- 
-- Procedure that selects an employee row given the employee
-- number and displays certain columns.
-- 

CREATE OR REPLACE PROCEDURE select_emp (
    p_empno        IN NUMBER
)
IS
    v_ename        emp.ename%TYPE;
    v_hiredate    emp.hiredate%TYPE;
    v_sal         emp.sal%TYPE;
    v_comm        emp.comm%TYPE;
    v_dname        dept.dname%TYPE;
    v_disp_date   VARCHAR2(10);
BEGIN
    SELECT ename, hiredate, sal, NVL(comm, 0), dname
        INTO v_ename, v_hiredate, v_sal, v_comm, v_dname
        FROM emp e, dept d
        WHERE empno = p_empno

```

```

        AND e.deptno = d.deptno;
        v_disp_date := TO_CHAR(v_hiredate, 'MM/DD/YYYY');
        DBMS_OUTPUT.PUT_LINE('Number      : ' || p_empno);
        DBMS_OUTPUT.PUT_LINE('Name       : ' || v_ename);
        DBMS_OUTPUT.PUT_LINE('Hire Date : ' || v_disp_date);
        DBMS_OUTPUT.PUT_LINE('Salary     : ' || v_sal);
        DBMS_OUTPUT.PUT_LINE('Commission: ' || v_com);
        DBMS_OUTPUT.PUT_LINE('Department: ' || v_dname);
EXCEPTION
    WHEN NO_DATA_FOUND THEN
        DBMS_OUTPUT.PUT_LINE('Employee ' || p_empno || ' not found');
    WHEN OTHERS THEN
        DBMS_OUTPUT.PUT_LINE('The following is SQLERRM:');
        DBMS_OUTPUT.PUT_LINE(SQLERRM);
        DBMS_OUTPUT.PUT_LINE('The following is SQLCODE:');
        DBMS_OUTPUT.PUT_LINE(SQLCODE);
END;
/
-- Procedure that queries the 'emp' table based on
-- department number and employee number or name. Returns
-- employee number and name as IN OUT parameters and job,
-- hire date, and salary as OUT parameters.
--
CREATE OR REPLACE PROCEDURE emp_query (
    p_deptno      IN      NUMBER,
    p_empno       IN OUT NUMBER,
    p_ename        IN OUT VARCHAR2,
    p_job          OUT     VARCHAR2,
    p_hiredate    OUT     DATE,
    p_sal          OUT     NUMBER
)
IS
BEGIN
    SELECT empno, ename, job, hiredate, sal
        INTO p_empno, p_ename, p_job, p_hiredate, p_sal
        FROM emp
        WHERE deptno = p_deptno
            AND (empno = p_empno
            OR ename = UPPER(p_ename));
END;
/
-- Procedure to call 'emp_query_caller' with IN and IN OUT
-- parameters. Displays the results received from IN OUT and
-- OUT parameters.
--
CREATE OR REPLACE PROCEDURE emp_query_caller
IS
    v_deptno      NUMBER(2);
    v_empno       NUMBER(4);
    v_ename        VARCHAR2(10);
    v_job          VARCHAR2(9);
    v_hiredate    DATE;
    v_sal          NUMBER;
BEGIN
    v_deptno := 30;
    v_empno := 0;
    v_ename := 'Martin';
    emp_query(v_deptno, v_empno, v_ename, v_job, v_hiredate, v_sal);
    DBMS_OUTPUT.PUT_LINE('Department : ' || v_deptno);
    DBMS_OUTPUT.PUT_LINE('Employee No: ' || v_empno);
    DBMS_OUTPUT.PUT_LINE('Name       : ' || v_ename);

```

```

DBMS_OUTPUT.PUT_LINE('Job          : ' || v_job);
DBMS_OUTPUT.PUT_LINE('Hire Date   : ' || v_hiredate);
DBMS_OUTPUT.PUT_LINE('Salary       : ' || v_sal);
EXCEPTION
    WHEN TOO_MANY_ROWS THEN
        DBMS_OUTPUT.PUT_LINE('More than one employee was selected');
    WHEN NO_DATA_FOUND THEN
        DBMS_OUTPUT.PUT_LINE('No employees were selected');
END;
/
---

-- Function to compute yearly compensation based on semimonthly
-- salary.
--

CREATE OR REPLACE FUNCTION emp_comp (
    p_sal           NUMBER,
    p_comm          NUMBER
) RETURN NUMBER
IS
BEGIN
    RETURN (p_sal + NVL(p_comm, 0)) * 24;
END;
/
---

-- Function that gets the next number from sequence, 'next_empno',
-- and ensures it is not already in use as an employee number.
--

CREATE OR REPLACE FUNCTION new_empno RETURN NUMBER
IS
    v_cnt            INTEGER := 1;
    v_new_empno      NUMBER;
BEGIN
    WHILE v_cnt > 0 LOOP
        SELECT next_empno.nextval INTO v_new_empno FROM dual;
        SELECT COUNT(*) INTO v_cnt FROM emp WHERE empno = v_new_empno;
    END LOOP;
    RETURN v_new_empno;
END;
/
---

-- EDB-SPL function that adds a new clerk to table 'emp'. This function
-- uses package 'emp_admin'.
--

CREATE OR REPLACE FUNCTION hire_clerk (
    p_ename          VARCHAR2,
    p_deptno         NUMBER
) RETURN NUMBER
IS
    v_empno          NUMBER(4);
    v_ename          VARCHAR2(10);
    v_job            VARCHAR2(9);
    v_mgr            NUMBER(4);
    v_hiredate       DATE;
    v_sal             NUMBER(7,2);
    v_comm            NUMBER(7,2);
    v_deptno          NUMBER(2);
BEGIN
    v_empno := new_empno;
    INSERT INTO emp VALUES (v_empno, p_ename, 'CLERK', 7782,
                           TRUNC(SYSDATE), 950.00, NULL, p_deptno);
    SELECT empno, ename, job, mgr, hiredate, sal, comm, deptno INTO
        v_empno, v_ename, v_job, v_mgr, v_hiredate, v_sal, v_comm, v_deptno
    FROM emp WHERE empno = v_empno;

```

```

DBMS_OUTPUT.PUT_LINE('Department : ' || v_deptno);
DBMS_OUTPUT.PUT_LINE('Employee No: ' || v_empno);
DBMS_OUTPUT.PUT_LINE('Name      : ' || v_ename);
DBMS_OUTPUT.PUT_LINE('Job       : ' || v_job);
DBMS_OUTPUT.PUT_LINE('Manager    : ' || v_mgr);
DBMS_OUTPUT.PUT_LINE('Hire Date : ' || v_hiredate);
DBMS_OUTPUT.PUT_LINE('Salary     : ' || v_sal);
DBMS_OUTPUT.PUT_LINE('Commission : ' || v_comm);
RETURN v_empno;
EXCEPTION
  WHEN OTHERS THEN
    DBMS_OUTPUT.PUT_LINE('The following is SQLERRM:');
    DBMS_OUTPUT.PUT_LINE(SQLERRM);
    DBMS_OUTPUT.PUT_LINE('The following is SQLCODE:');
    DBMS_OUTPUT.PUT_LINE(SQLCODE);
    RETURN -1;
END;
/
-- 
-- PostgreSQL PL/pgSQL function that adds a new salesman
-- to table 'emp'.
-- 

CREATE OR REPLACE FUNCTION hire_salesman (
  p_ename      VARCHAR,
  p_sal        NUMERIC,
  p_comm       NUMERIC
) RETURNS NUMERIC
AS $$$
DECLARE
  v_empno      NUMERIC(4);
  v_ename      VARCHAR(10);
  v_job        VARCHAR(9);
  v_mgr        NUMERIC(4);
  v_hiredate   DATE;
  v_sal        NUMERIC(7,2);
  v_comm       NUMERIC(7,2);
  v_deptno     NUMERIC(2);
BEGIN
  v_empno := new_empno();
  INSERT INTO emp VALUES (v_empno, p_ename, 'SALESMAN', 7698,
                         CURRENT_DATE, p_sal, p_comm, 30);
  SELECT INTO
    v_empno, v_ename, v_job, v_mgr, v_hiredate, v_sal, v_comm, v_deptno
    empno, ename, job, mgr, hiredate, sal, comm, deptno
  FROM emp WHERE empno = v_empno;
  RAISE INFO 'Department : %', v_deptno;
  RAISE INFO 'Employee No: %', v_empno;
  RAISE INFO 'Name      : %', v_ename;
  RAISE INFO 'Job       : %', v_job;
  RAISE INFO 'Manager    : %', v_mgr;
  RAISE INFO 'Hire Date : %', v_hiredate;
  RAISE INFO 'Salary     : %', v_sal;
  RAISE INFO 'Commission : %', v_comm;
  RETURN v_empno;
EXCEPTION
  WHEN OTHERS THEN
    RAISE INFO 'The following is SQLERRM:';
    RAISE INFO '%', SQLERRM;
    RAISE INFO 'The following is SQLSTATE:';
    RAISE INFO '%', SQLSTATE;
    RETURN -1;
END;
$$ LANGUAGE 'plpgsql';

```

```

/
-- Rule to INSERT into view 'salesemp'
--
CREATE OR REPLACE RULE salesemp_i AS ON INSERT TO salesemp
DO INSTEAD
    INSERT INTO emp VALUES (NEW.empno, NEW.ename, 'SALESMAN', 7698,
                           NEW.hiredate, NEW.sal, NEW.comm, 30);
--
-- Rule to UPDATE view 'salesemp'
--
CREATE OR REPLACE RULE salesemp_u AS ON UPDATE TO salesemp
DO INSTEAD
    UPDATE emp SET empno      = NEW.empno,
                  ename       = NEW.ename,
                  hiredate   = NEW.hiredate,
                  sal        = NEW.sal,
                  comm       = NEW.comm
    WHERE empno = OLD.empno;
--
-- Rule to DELETE from view 'salesemp'
--
CREATE OR REPLACE RULE salesemp_d AS ON DELETE TO salesemp
DO INSTEAD
    DELETE FROM emp WHERE empno = OLD.empno;
--
-- After statement-level trigger that displays a message after
-- an insert, update, or deletion to the 'emp' table. One message
-- per SQL command is displayed.
--
CREATE OR REPLACE TRIGGER user_audit_trig
    AFTER INSERT OR UPDATE OR DELETE ON emp
DECLARE
    v_action      VARCHAR2(24);
BEGIN
    IF INSERTING THEN
        v_action := ' added employee(s) on ';
    ELSIF UPDATING THEN
        v_action := ' updated employee(s) on ';
    ELSIF DELETING THEN
        v_action := ' deleted employee(s) on ';
    END IF;
    DBMS_OUTPUT.PUT_LINE('User ' || USER || v_action ||
TO_CHAR(SYSDATE,'YYYY-MM-DD'));
END;
/
--
-- Before row-level trigger that displays employee number and
-- salary of an employee that is about to be added, updated,
-- or deleted in the 'emp' table.
--
CREATE OR REPLACE TRIGGER emp_sal_trig
    BEFORE DELETE OR INSERT OR UPDATE ON emp
    FOR EACH ROW
DECLARE
    sal_diff      NUMBER;
BEGIN
    IF INSERTING THEN
        DBMS_OUTPUT.PUT_LINE('Inserting employee ' || :NEW.empno);
        DBMS_OUTPUT.PUT_LINE('..New salary: ' || :NEW.sal);
    END IF;
    IF UPDATING THEN
        sal_diff := :NEW.sal - :OLD.sal;
    END IF;
END;
/

```

```

        DBMS_OUTPUT.PUT_LINE('Updating employee ' || :OLD.empno);
        DBMS_OUTPUT.PUT_LINE(..Old salary: ' || :OLD.sal);
        DBMS_OUTPUT.PUT_LINE(..New salary: ' || :NEW.sal);
        DBMS_OUTPUT.PUT_LINE(..Raise      : ' || sal_diff);
    END IF;
    IF DELETING THEN
        DBMS_OUTPUT.PUT_LINE('Deleting employee ' || :OLD.empno);
        DBMS_OUTPUT.PUT_LINE(..Old salary: ' || :OLD.sal);
    END IF;
END;
/
-- 
-- Package specification for the 'emp_admin' package.
-- 
CREATE OR REPLACE PACKAGE emp_admin
IS
    FUNCTION get_dept_name (
        p_deptno      NUMBER
    ) RETURN VARCHAR2;
    FUNCTION update_emp_sal (
        p_empno       NUMBER,
        p_raise       NUMBER
    ) RETURN NUMBER;
    PROCEDURE hire_emp (
        p_empno       NUMBER,
        p_ename        VARCHAR2,
        p_job          VARCHAR2,
        p_sal          NUMBER,
        p_hiredate    DATE,
        p_comm         NUMBER,
        p_mgr          NUMBER,
        p_deptno      NUMBER
    );
    PROCEDURE fire_emp (
        p_empno       NUMBER
    );
END emp_admin;
/
-- 
-- Package body for the 'emp_admin' package.
-- 
CREATE OR REPLACE PACKAGE BODY emp_admin
IS
    --
    -- Function that queries the 'dept' table based on the department
    -- number and returns the corresponding department name.
    --
    FUNCTION get_dept_name (
        p_deptno      IN NUMBER
    ) RETURN VARCHAR2
    IS
        v_dname        VARCHAR2(14);
    BEGIN
        SELECT dname INTO v_dname FROM dept WHERE deptno = p_deptno;
        RETURN v_dname;
    EXCEPTION
        WHEN NO_DATA_FOUND THEN
            DBMS_OUTPUT.PUT_LINE('Invalid department number ' || p_deptno);
            RETURN '';
    END;
    --
    -- Function that updates an employee's salary based on the
    -- employee number and salary increment/decrement passed

```

```

-- as IN parameters. Upon successful completion the function
-- returns the new updated salary.
--
FUNCTION update_emp_sal (
    p_empno          IN NUMBER,
    p_raise           IN NUMBER
) RETURN NUMBER
IS
    v_sal             NUMBER := 0;
BEGIN
    SELECT sal INTO v_sal FROM emp WHERE empno = p_empno;
    v_sal := v_sal + p_raise;
    UPDATE emp SET sal = v_sal WHERE empno = p_empno;
    RETURN v_sal;
EXCEPTION
    WHEN NO_DATA_FOUND THEN
        DBMS_OUTPUT.PUT_LINE('Employee ' || p_empno || ' not found');
        RETURN -1;
    WHEN OTHERS THEN
        DBMS_OUTPUT.PUT_LINE('The following is SQLERRM:');
        DBMS_OUTPUT.PUT_LINE(SQLERRM);
        DBMS_OUTPUT.PUT_LINE('The following is SQLCODE:');
        DBMS_OUTPUT.PUT_LINE(SQLCODE);
        RETURN -1;
END;
--
-- Procedure that inserts a new employee record into the 'emp' table.
--
PROCEDURE hire_emp (
    p_empno          NUMBER,
    p_ename           VARCHAR2,
    p_job             VARCHAR2,
    p_sal             NUMBER,
    p_hiredate        DATE,
    p_comm            NUMBER,
    p_mgr             NUMBER,
    p_deptno          NUMBER
)
AS
BEGIN
    INSERT INTO emp(empno, ename, job, sal, hiredate, comm, mgr, deptno)
        VALUES(p_empno, p_ename, p_job, p_sal,
               p_hiredate, p_comm, p_mgr, p_deptno);
END;
--
-- Procedure that deletes an employee record from the 'emp' table based
-- on the employee number.
--
PROCEDURE fire_emp (
    p_empno          NUMBER
)
AS
BEGIN
    DELETE FROM emp WHERE empno = p_empno;
END;
/
COMMIT;

```

2.1.2 Creating a New Table

A new table is created by specifying the table name, along with all column names and their types. The following is a simplified version of the `emp` sample table with just the minimal information needed to define a table.

```
CREATE TABLE emp (
    empno      NUMBER (4),
    ename      VARCHAR2 (10),
    job        VARCHAR2 (9),
    mgr        NUMBER (4),
    hiredate   DATE,
    sal        NUMBER (7, 2),
    comm       NUMBER (7, 2),
    deptno    NUMBER (2)
);
```

You can enter this into PSQL with line breaks. PSQL will recognize that the command is not terminated until the semicolon.

White space (i.e., spaces, tabs, and newlines) may be used freely in SQL commands. That means you can type the command aligned differently than the above, or even all on one line. Two dashes ("--") introduce comments. Whatever follows them is ignored up to the end of the line. SQL is case insensitive about key words and identifiers, except when identifiers are double-quoted to preserve the case (not done above).

`VARCHAR2 (10)` specifies a data type that can store arbitrary character strings up to 10 characters in length. `NUMBER (7, 2)` is a fixed point number with precision 7 and scale 2. `NUMBER (4)` is an integer number with precision 4 and scale 0.

Advanced Server supports the usual SQL data types `INTEGER`, `SMALLINT`, `NUMBER`, `REAL`, `DOUBLE PRECISION`, `CHAR`, `VARCHAR2`, `DATE`, and `TIMESTAMP` as well as various synonyms for these types.

If you don't need a table any longer or want to recreate it differently you can remove it using the following command:

```
DROP TABLE tablename;
```

2.1.3 Populating a Table With Rows

The `INSERT` statement is used to populate a table with rows:

```
INSERT INTO emp VALUES (7369, 'SMITH', 'CLERK', 7902, '17-DEC-80', 800, NULL, 20);
```

Note that all data types use rather obvious input formats. Constants that are not simple numeric values usually must be surrounded by single quotes ('), as in the example. The `DATE` type is actually quite flexible in what it accepts, but for this tutorial we will stick to the unambiguous format shown here.

The syntax used so far requires you to remember the order of the columns. An alternative syntax allows you to list the columns explicitly:

```
INSERT INTO emp (empno,ename,job,mgr,hiredate,sal,comm,deptno)
VALUES (7499,'ALLEN','SALESMAN',7698,'20-FEB-81',1600,300,30);
```

You can list the columns in a different order if you wish or even omit some columns, e.g., if the commission is unknown:

```
INSERT INTO emp (empno,ename,job,mgr,hiredate,sal,deptno)
VALUES (7369,'SMITH','CLERK',7902,'17-DEC-80',800,20);
```

Many developers consider explicitly listing the columns better style than relying on the order implicitly.

2.1.4 Querying a Table

To retrieve data from a table, the table is *queried*. An SQL SELECT statement is used to do this. The statement is divided into a select list (the part that lists the columns to be returned), a table list (the part that lists the tables from which to retrieve the data), and an optional qualification (the part that specifies any restrictions). The following query lists all columns of all employees in the table in no particular order.

```
SELECT * FROM emp;
```

Here, “*” in the select list means all columns. The following is the output from this query.

empno	ename	job	mgr	hiredate	sal	comm	deptno
7369	SMITH	CLERK	7902	17-DEC-80 00:00:00	800.00		20
7499	ALLEN	SALESMAN	7698	20-FEB-81 00:00:00	1600.00	300.00	30
7521	WARD	SALESMAN	7698	22-FEB-81 00:00:00	1250.00	500.00	30
7566	JONES	MANAGER	7839	02-APR-81 00:00:00	2975.00		20
7654	MARTIN	SALESMAN	7698	28-SEP-81 00:00:00	1250.00	1400.00	30
7698	BLAKE	MANAGER	7839	01-MAY-81 00:00:00	2850.00		30
7782	CLARK	MANAGER	7839	09-JUN-81 00:00:00	2450.00		10
7788	SCOTT	ANALYST	7566	19-APR-87 00:00:00	3000.00		20
7839	KING	PRESIDENT		17-NOV-81 00:00:00	5000.00		10
7844	TURNER	SALESMAN	7698	08-SEP-81 00:00:00	1500.00	0.00	30
7876	ADAMS	CLERK	7788	23-MAY-87 00:00:00	1100.00		20
7900	JAMES	CLERK	7698	03-DEC-81 00:00:00	950.00		30
7902	FORD	ANALYST	7566	03-DEC-81 00:00:00	3000.00		20
7934	MILLER	CLERK	7782	23-JAN-82 00:00:00	1300.00		10

(14 rows)

You may specify any arbitrary expression in the select list. For example, you can do:

ename	sal	yearly_salary	deptno
SMITH	800.00	19200.00	20
ALLEN	1600.00	38400.00	30
WARD	1250.00	30000.00	30
JONES	2975.00	71400.00	20
MARTIN	1250.00	30000.00	30
BLAKE	2850.00	68400.00	30
CLARK	2450.00	58800.00	10
SCOTT	3000.00	72000.00	20
KING	5000.00	120000.00	10
TURNER	1500.00	36000.00	30
ADAMS	1100.00	26400.00	20
JAMES	950.00	22800.00	30
FORD	3000.00	72000.00	20
MILLER	1300.00	31200.00	10

(14 rows)

Notice how the AS clause is used to re-label the output column. (The AS clause is optional.)

A query can be qualified by adding a `WHERE` clause that specifies which rows are wanted. The `WHERE` clause contains a Boolean (truth value) expression, and only rows for which the Boolean expression is true are returned. The usual Boolean operators (`AND`, `OR`, and `NOT`) are allowed in the qualification. For example, the following retrieves the employees in department 20 with salaries over \$1000.00:

```
SELECT ename, sal, deptno FROM emp WHERE deptno = 20 AND sal > 1000;

ename |    sal    | deptno
-----+-----+-----
JONES | 2975.00 |    20
SCOTT | 3000.00 |    20
ADAMS | 1100.00 |    20
FORD  | 3000.00 |    20
(4 rows)
```

You can request that the results of a query be returned in sorted order:

```
SELECT ename, sal, deptno FROM emp ORDER BY ename;

ename |    sal    | deptno
-----+-----+-----
ADAMS | 1100.00 |    20
ALLEN | 1600.00 |    30
BLAKE | 2850.00 |    30
CLARK | 2450.00 |    10
FORD  | 3000.00 |    20
JAMES |  950.00 |    30
JONES | 2975.00 |    20
KING  | 5000.00 |    10
MARTIN | 1250.00 |    30
MILLER | 1300.00 |    10
SCOTT | 3000.00 |    20
SMITH  |  800.00 |    20
TURNER | 1500.00 |    30
WARD   | 1250.00 |    30
(14 rows)
```

You can request that duplicate rows be removed from the result of a query:

```
SELECT DISTINCT job FROM emp;

job
-----
ANALYST
CLERK
MANAGER
PRESIDENT
SALESMAN
(5 rows)
```

The following section shows how to obtain rows from more than one table in a single query.

2.1.5 Joins Between Tables

Thus far, our queries have only accessed one table at a time. Queries can access multiple tables at once, or access the same table in such a way that multiple rows of the table are being processed at the same time. A query that accesses multiple rows of the same or different tables at one time is called a *join* query. For example, say you wish to list all the employee records together with the name and location of the associated department. To do that, we need to compare the `deptno` column of each row of the `emp` table with the `deptno` column of all rows in the `dept` table, and select the pairs of rows where these values match. This would be accomplished by the following query:

```
SELECT emp.ename, emp.sal, dept.deptno, dept.dname, dept.loc FROM emp, dept
WHERE emp.deptno = dept.deptno;
```

ename	sal	deptno	dname	loc
MILLER	1300.00	10	ACCOUNTING	NEW YORK
CLARK	2450.00	10	ACCOUNTING	NEW YORK
KING	5000.00	10	ACCOUNTING	NEW YORK
SCOTT	3000.00	20	RESEARCH	DALLAS
JONES	2975.00	20	RESEARCH	DALLAS
SMITH	800.00	20	RESEARCH	DALLAS
ADAMS	1100.00	20	RESEARCH	DALLAS
FORD	3000.00	20	RESEARCH	DALLAS
WARD	1250.00	30	SALES	CHICAGO
TURNER	1500.00	30	SALES	CHICAGO
ALLEN	1600.00	30	SALES	CHICAGO
BLAKE	2850.00	30	SALES	CHICAGO
MARTIN	1250.00	30	SALES	CHICAGO
JAMES	950.00	30	SALES	CHICAGO

(14 rows)

Observe two things about the result set:

- There is no result row for department 40. This is because there is no matching entry in the `emp` table for department 40, so the join ignores the unmatched rows in the `dept` table. Shortly we will see how this can be fixed.
- It is more desirable to list the output columns qualified by table name rather than using * or leaving out the qualification as follows:

```
SELECT ename, sal, dept.deptno, dname, loc FROM emp, dept WHERE emp.deptno =
dept.deptno;
```

Since all the columns had different names (except for `deptno` which therefore must be qualified), the parser automatically found out which table they belong to, but it is good style to fully qualify column names in join queries:

Join queries of the kind seen thus far can also be written in this alternative form:

```
SELECT emp.ename, emp.sal, dept.deptno, dept.dname, dept.loc FROM emp INNER
JOIN dept ON emp.deptno = dept.deptno;
```

This syntax is not as commonly used as the one above, but we show it here to help you understand the following topics.

You will notice that in all the above results for joins no employees were returned that belonged to department 40 and as a consequence, the record for department 40 never appears. Now we will figure out how we can get the department 40 record in the results despite the fact that there are no matching employees. What we want the query to do is to scan the `dept` table and for each row to find the matching `emp` row. If no matching row is found we want some “empty” values to be substituted for the `emp` table’s columns. This kind of query is called an *outerjoin*. (The joins we have seen so far are *innerjoins*.) The command looks like this:

```
SELECT emp.ename, emp.sal, dept.deptno, dept.dname, dept.loc FROM dept LEFT
OUTER JOIN emp ON emp.deptno = dept.deptno;
```

ename	sal	deptno	dname	loc
MILLER	1300.00	10	ACCOUNTING	NEW YORK
CLARK	2450.00	10	ACCOUNTING	NEW YORK
KING	5000.00	10	ACCOUNTING	NEW YORK
SCOTT	3000.00	20	RESEARCH	DALLAS
JONES	2975.00	20	RESEARCH	DALLAS
SMITH	800.00	20	RESEARCH	DALLAS
ADAMS	1100.00	20	RESEARCH	DALLAS
FORD	3000.00	20	RESEARCH	DALLAS
WARD	1250.00	30	SALES	CHICAGO
TURNER	1500.00	30	SALES	CHICAGO
ALLEN	1600.00	30	SALES	CHICAGO
BLAKE	2850.00	30	SALES	CHICAGO
MARTIN	1250.00	30	SALES	CHICAGO
JAMES	950.00	30	SALES	CHICAGO
		40	OPERATIONS	BOSTON

(15 rows)

This query is called a *left outerjoin* because the table mentioned on the left of the join operator will have each of its rows in the output at least once, whereas the table on the right will only have those rows output that match some row of the left table. When a left-table row is selected for which there is no right-table match, empty (NULL) values are substituted for the right-table columns.

An alternative syntax for an outer join is to use the outer join operator, “(+)”, in the join condition within the `WHERE` clause. The outer join operator is placed after the column name of the table for which null values should be substituted for unmatched rows. So for all the rows in the `dept` table that have no matching rows in the `emp` table, Advanced Server returns null for any select list expressions containing columns of `emp`. Hence the above example could be rewritten as:

```
SELECT emp.ename, emp.sal, dept.deptno, dept.dname, dept.loc FROM dept, emp
WHERE emp.deptno(+) = dept.deptno;
```

ename	sal	deptno	dname	loc
MILLER	1300.00	10	ACCOUNTING	NEW YORK
CLARK	2450.00	10	ACCOUNTING	NEW YORK
KING	5000.00	10	ACCOUNTING	NEW YORK
SCOTT	3000.00	20	RESEARCH	DALLAS
JONES	2975.00	20	RESEARCH	DALLAS
SMITH	800.00	20	RESEARCH	DALLAS
ADAMS	1100.00	20	RESEARCH	DALLAS
FORD	3000.00	20	RESEARCH	DALLAS
WARD	1250.00	30	SALES	CHICAGO
TURNER	1500.00	30	SALES	CHICAGO
ALLEN	1600.00	30	SALES	CHICAGO
BLAKE	2850.00	30	SALES	CHICAGO
MARTIN	1250.00	30	SALES	CHICAGO
JAMES	950.00	30	SALES	CHICAGO
		40	OPERATIONS	BOSTON

(15 rows)

We can also join a table against itself. This is called a *selfjoin*. As an example, suppose we wish to find the name of each employee along with the name of that employee's manager. So we need to compare the `mgr` column of each `emp` row to the `empno` column of all other `emp` rows.

```
SELECT e1.ename || ' works for ' || e2.ename AS "Employees and their Managers"
FROM emp e1, emp e2 WHERE e1.mgr = e2.empno;
```

Employees and their Managers

```
-----  
FORD works for JONES  
SCOTT works for JONES  
WARD works for BLAKE  
TURNER works for BLAKE  
MARTIN works for BLAKE  
JAMES works for BLAKE  
ALLEN works for BLAKE  
MILLER works for CLARK  
ADAMS works for SCOTT  
CLARK works for KING  
BLAKE works for KING  
JONES works for KING  
SMITH works for FORD  
(13 rows)
```

Here, the `emp` table has been re-labeled as `e1` to represent the employee row in the select list and in the join condition, and also as `e2` to represent the matching employee row acting as manager in the select list and in the join condition. These kinds of aliases can be used in other queries to save some typing, for example:

```
SELECT e.ename, e.mgr, d.deptno, d.dname, d.loc FROM emp e, dept d WHERE
e.deptno = d.deptno;
```

ename	mgr	deptno	dname	loc
MILLER	7782	10	ACCOUNTING	NEW YORK
CLARK	7839	10	ACCOUNTING	NEW YORK
KING		10	ACCOUNTING	NEW YORK
SCOTT	7566	20	RESEARCH	DALLAS

JONES		7839		20		RESEARCH		DALLAS
SMITH		7902		20		RESEARCH		DALLAS
ADAMS		7788		20		RESEARCH		DALLAS
FORD		7566		20		RESEARCH		DALLAS
WARD		7698		30		SALES		CHICAGO
TURNER		7698		30		SALES		CHICAGO
ALLEN		7698		30		SALES		CHICAGO
BLAKE		7839		30		SALES		CHICAGO
MARTIN		7698		30		SALES		CHICAGO
JAMES		7698		30		SALES		CHICAGO
(14 rows)								

This style of abbreviating will be encountered quite frequently.

2.1.6 Aggregate Functions

Like most other relational database products, Advanced Server supports aggregate functions. An aggregate function computes a single result from multiple input rows. For example, there are aggregates to compute the COUNT, SUM, AVG (average), MAX (maximum), and MIN (minimum) over a set of rows.

As an example, the highest and lowest salaries can be found with the following query:

```
SELECT MAX(sal) highest_salary, MIN(sal) lowest_salary FROM emp;

highest_salary | lowest_salary
-----+-----
      5000.00 |       800.00
(1 row)
```

If we wanted to find the employee with the largest salary, we may be tempted to try:

```
SELECT ename FROM emp WHERE sal = MAX(sal);

ERROR: aggregates not allowed in WHERE clause
```

This does not work because the aggregate function, MAX, cannot be used in the WHERE clause. This restriction exists because the WHERE clause determines the rows that will go into the aggregation stage so it has to be evaluated before aggregate functions are computed. However, the query can be restated to accomplish the intended result by using a *subquery*:

```
SELECT ename FROM emp WHERE sal = (SELECT MAX(sal) FROM emp);

ename
-----
KING
(1 row)
```

The subquery is an independent computation that obtains its own result separately from the outer query.

Aggregates are also very useful in combination with the GROUP BY clause. For example, the following query gets the highest salary in each department.

```
SELECT deptno, MAX(sal) FROM emp GROUP BY deptno;

deptno |   max
-----+-----
    10 | 5000.00
    20 | 3000.00
    30 | 2850.00
(3 rows)
```

This query produces one output row per department. Each aggregate result is computed over the rows matching that department. These grouped rows can be filtered using the HAVING clause.

```
SELECT deptno, MAX(sal) FROM emp GROUP BY deptno HAVING AVG(sal) > 2000;

deptno | max
-----+-----
 10  | 5000.00
 20  | 3000.00
(2 rows)
```

This query gives the same results for only those departments that have an average salary greater than 2000.

Finally, the following query takes into account only the highest paid employees who are analysts in each department.

```
SELECT deptno, MAX(sal) FROM emp WHERE job = 'ANALYST' GROUP BY deptno HAVING
AVG(sal) > 2000;

deptno | max
-----+-----
 20  | 3000.00
(1 row)
```

There is a subtle distinction between the WHERE and HAVING clauses. The WHERE clause filters out rows before grouping occurs and aggregate functions are applied. The HAVING clause applies filters on the results after rows have been grouped and aggregate functions have been computed for each group.

So in the previous example, only employees who are analysts are considered. From this subset, the employees are grouped by department and only those groups where the average salary of analysts in the group is greater than 2000 are in the final result. This is true of only the group for department 20 and the maximum analyst salary in department 20 is 3000.00.

2.1.7 Updates

The column values of existing rows can be changed using the UPDATE command. For example, the following sequence of commands shows the before and after results of giving everyone who is a manager a 10% raise:

```
SELECT ename, sal FROM emp WHERE job = 'MANAGER';

ename |    sal
-----+-----
JONES | 2975.00
BLAKE | 2850.00
CLARK | 2450.00
(3 rows)

UPDATE emp SET sal = sal * 1.1 WHERE job = 'MANAGER';

SELECT ename, sal FROM emp WHERE job = 'MANAGER';

ename |    sal
-----+-----
JONES | 3272.50
BLAKE | 3135.00
CLARK | 2695.00
(3 rows)
```

2.1.8 Deletions

Rows can be removed from a table using the `DELETE` command. For example, the following sequence of commands shows the before and after results of deleting all employees in department 20.

```
SELECT ename, deptno FROM emp;

ename | deptno
-----+-----
SMITH |    20
ALLEN |    30
WARD  |    30
JONES  |    20
MARTIN |    30
BLAKE  |    30
CLARK  |    10
SCOTT  |    20
KING   |    10
TURNER |    30
ADAMS  |    20
JAMES  |    30
FORD   |    20
MILLER |    10
(14 rows)

DELETE FROM emp WHERE deptno = 20;

SELECT ename, deptno FROM emp;
ename | deptno
-----+-----
ALLEN |    30
WARD  |    30
MARTIN |    30
BLAKE  |    30
CLARK  |    10
KING   |    10
TURNER |    30
JAMES  |    30
MILLER |    10
(9 rows)
```

Be extremely careful of giving a `DELETE` command without a `WHERE` clause such as the following:

```
DELETE FROM tablename;
```

This statement will remove all rows from the given table, leaving it completely empty. The system will not request confirmation before doing this.

2.1.9 The SQL Language

Advanced Server supports SQL language that is compatible with Oracle syntax as well as syntax and commands for extended functionality (functionality that does not provide database compatibility for Oracle or support Oracle-styled applications).

The Reference Guide that supports the Database Compatibility for Oracle Developer's Guide provides detailed information about:

- Compatible SQL syntax and language elements
- Data types
- Supported SQL command syntax

To review a copy of the Reference Guide, visit the Advanced Server website at:

<http://www.enterprisedb.com/products-services-training/products/documentation>

2.2 Advanced Concepts

The previous section discussed the basics of using SQL to store and access your data in Advanced Server. This section discusses more advanced SQL features that may simplify management and prevent loss or corruption of your data.

2.2.1 Views

Consider the following SELECT command.

```
SELECT ename, sal, sal * 24 AS yearly_salary, deptno FROM emp;

ename |    sal    | yearly_salary | deptno
-----+-----+-----+-----
SMITH | 800.00 | 19200.00 | 20
ALLEN | 1600.00 | 38400.00 | 30
WARD  | 1250.00 | 30000.00 | 30
JONES  | 2975.00 | 71400.00 | 20
MARTIN | 1250.00 | 30000.00 | 30
BLAKE  | 2850.00 | 68400.00 | 30
CLARK  | 2450.00 | 58800.00 | 10
SCOTT  | 3000.00 | 72000.00 | 20
KING   | 5000.00 | 120000.00 | 10
TURNER | 1500.00 | 36000.00 | 30
ADAMS  | 1100.00 | 26400.00 | 20
JAMES  | 950.00 | 22800.00 | 30
FORD   | 3000.00 | 72000.00 | 20
MILLER | 1300.00 | 31200.00 | 10
(14 rows)
```

If this is a query that is used repeatedly, a shorthand method of reusing this query without re-typing the entire SELECT command each time is to create a *view* as shown below.

```
CREATE VIEW employee_pay AS SELECT ename, sal, sal * 24 AS yearly_salary,
deptno FROM emp;
```

The view name, employee_pay, can now be used like an ordinary table name to perform the query.

```
SELECT * FROM employee_pay;

ename |    sal    | yearly_salary | deptno
-----+-----+-----+-----
SMITH | 800.00 | 19200.00 | 20
ALLEN | 1600.00 | 38400.00 | 30
WARD  | 1250.00 | 30000.00 | 30
JONES  | 2975.00 | 71400.00 | 20
MARTIN | 1250.00 | 30000.00 | 30
BLAKE  | 2850.00 | 68400.00 | 30
CLARK  | 2450.00 | 58800.00 | 10
SCOTT  | 3000.00 | 72000.00 | 20
KING   | 5000.00 | 120000.00 | 10
TURNER | 1500.00 | 36000.00 | 30
ADAMS  | 1100.00 | 26400.00 | 20
JAMES  | 950.00 | 22800.00 | 30
FORD   | 3000.00 | 72000.00 | 20
```

```
MILLER | 1300.00 |      31200.00 |     10  
(14 rows)
```

Making liberal use of views is a key aspect of good SQL database design. Views provide a consistent interface that encapsulate details of the structure of your tables which may change as your application evolves.

Views can be used in almost any place a real table can be used. Building views upon other views is not uncommon.

2.2.2 Foreign Keys

Suppose you want to make sure all employees belong to a valid department. This is called maintaining the *referential integrity* of your data. In simplistic database systems this would be implemented (if at all) by first looking at the `dept` table to check if a matching record exists, and then inserting or rejecting the new employee record. This approach has a number of problems and is very inconvenient. Advanced Server can make it easier for you.

A modified version of the `emp` table presented in Section 2.1.2 is shown in this section with the addition of a foreign key constraint. The modified `emp` table looks like the following:

```
CREATE TABLE emp (
    empno      NUMBER(4) NOT NULL CONSTRAINT emp_pk PRIMARY KEY,
    ename      VARCHAR2(10),
    job        VARCHAR2(9),
    mgr        NUMBER(4),
    hiredate   DATE,
    sal         NUMBER(7, 2),
    comm       NUMBER(7, 2),
    deptno     NUMBER(2) CONSTRAINT emp_ref_dept_fk
                REFERENCES dept(deptno)
);
```

If an attempt is made to issue the following `INSERT` command in the sample `emp` table, the foreign key constraint, `emp_ref_dept_fk`, ensures that department 50 exists in the `dept` table. Since it does not, the command is rejected.

```
INSERT INTO emp VALUES (8000, 'JONES', 'CLERK', 7902, '17-AUG-07', 1200, NULL, 50);

ERROR: insert or update on table "emp" violates foreign key constraint
"emp_ref_dept_fk"
DETAIL: Key (deptno)=(50) is not present in table "dept".
```

The behavior of foreign keys can be finely tuned to your application. Making correct use of foreign keys will definitely improve the quality of your database applications, so you are strongly encouraged to learn more about them.

2.2.3 The ROWNUM Pseudo-Column

ROWNUM is a pseudo-column that is assigned an incremental, unique integer value for each row based on the order the rows were retrieved from a query. Therefore, the first row retrieved will have ROWNUM of 1; the second row will have ROWNUM of 2 and so on.

This feature can be used to limit the number of rows retrieved by a query. This is demonstrated in the following example:

```
SELECT empno, ename, job FROM emp WHERE ROWNUM < 5;

empno | ename | job
-----+-----+-----
 7369 | SMITH | CLERK
 7499 | ALLEN | SALESMAN
 7521 | WARD | SALESMAN
 7566 | JONES | MANAGER
(4 rows)
```

The ROWNUM value is assigned to each row before any sorting of the result set takes place. Thus, the result set is returned in the order given by the ORDER BY clause, but the ROWNUM values may not necessarily be in ascending order as shown in the following example:

```
SELECT ROWNUM, empno, ename, job FROM emp WHERE ROWNUM < 5 ORDER BY ename;

rownum | empno | ename | job
-----+-----+-----+-----
    2 | 7499 | ALLEN | SALESMAN
    4 | 7566 | JONES | MANAGER
    1 | 7369 | SMITH | CLERK
    3 | 7521 | WARD | SALESMAN
(4 rows)
```

The following example shows how a sequence number can be added to every row in the jobhist table. First a new column named, seqno, is added to the table and then seqno is set to ROWNUM in the UPDATE command.

```
ALTER TABLE jobhist ADD seqno NUMBER(3);
UPDATE jobhist SET seqno = ROWNUM;
```

The following SELECT command shows the new seqno values.

```
SELECT seqno, empno, TO_CHAR(startdate, 'DD-MON-YY') AS start, job FROM
jobhist;

seqno | empno | start      | job
-----+-----+-----+-----
  1 | 7369 | 17-DEC-80 | CLERK
  2 | 7499 | 20-FEB-81 | SALESMAN
  3 | 7521 | 22-FEB-81 | SALESMAN
  4 | 7566 | 02-APR-81 | MANAGER
```

Database Compatibility for Oracle® Developers Guide

5	7654	28-SEP-81	SALESMAN
6	7698	01-MAY-81	MANAGER
7	7782	09-JUN-81	MANAGER
8	7788	19-APR-87	CLERK
9	7788	13-APR-88	CLERK
10	7788	05-MAY-90	ANALYST
11	7839	17-NOV-81	PRESIDENT
12	7844	08-SEP-81	SALESMAN
13	7876	23-MAY-87	CLERK
14	7900	03-DEC-81	CLERK
15	7900	15-JAN-83	CLERK
16	7902	03-DEC-81	ANALYST
17	7934	23-JAN-82	CLERK

(17 rows)

2.2.4 Synonyms

A *synonym* is an identifier that can be used to reference another database object in a SQL statement. A synonym is useful in cases where a database object would normally require full qualification by schema name to be properly referenced in a SQL statement. A synonym defined for that object simplifies the reference to a single, unqualified name.

Advanced Server supports synonyms for:

- tables
- views
- materialized views
- sequences
- procedures
- functions
- types
- objects that are accessible through a database link
- other synonyms

Neither the referenced schema or referenced object must exist at the time that you create the synonym; a synonym may refer to a non-existent object or schema. A synonym will become invalid if you drop the referenced object or schema. You must explicitly drop a synonym to remove it.

As with any other schema object, Advanced Server uses the search path to resolve unqualified synonym names. If you have two synonyms with the same name, an unqualified reference to a synonym will resolve to the first synonym with the given name in the search path. If `public` is in your search path, you can refer to a synonym in that schema without qualifying that name.

When Advanced Server executes an SQL command, the privileges of the current user are checked against the synonym's underlying database object; if the user does not have the proper permissions for that object, the SQL command will fail.

Deleting a Synonym

To delete a synonym, use the command, `DROP SYNONYM`. The syntax is:

```
DROP [PUBLIC] SYNONYM [schema.] syn_name
```

Parameters:

syn_name

syn_name is the name of the synonym. A synonymname must be unique within a schema.

schema

schema specifies the name of the schema in which the synonymresides.

Like any other object that can be schema-qualified, you may have two synonyms with the same name in your search path. To disambiguate the name of the synonymthat you are dropping, include a schema name. Unless a synonymis schema qualified in the `DROP SYNONYM` command, Advanced Server deletes the first instance of the synonymit finds in your searchpath.

You can optionally include the `PUBLIC` clause to drop a synonymthat resides in the `public` schema. Compatible with Oracle databases, the `DROP PUBLIC SYNONYM` command drops a synonymthat resides in the `public` schema:

```
DROP PUBLIC SYNONYM syn_name;
```

The following example drops the synonym, `personnel`:

```
DROP SYNONYM personnel;
```

2.2.5 Hierarchical Queries

A *hierarchical query* is a type of query that returns the rows of the result set in a hierarchical order based upon data forming a parent-child relationship. A hierarchy is typically represented by an inverted tree structure. The tree is comprised of interconnected *nodes*. Each node may be connected to none, one, or multiple *child* nodes. Each node is connected to one *parent* node except for the top node which has no parent. This node is the *root* node. Each tree has exactly one rootnode. Nodes that don't have any children are called *leaf* nodes. A tree always has at least one leaf node - e.g., the trivial case where the tree is comprised of a single node. In this case it is both the root and the leaf.

In a hierarchical query the rows of the result set represent the nodes of one or more trees.

Note: It is possible that a single, given row may appear in more than one tree and thus appear more than once in the result set.

The hierarchical relationship in a query is described by the `CONNECT BY` clause which forms the basis of the order in which rows are returned in the result set. The context of where the `CONNECT BY` clause and its associated optional clauses appear in the `SELECT` command is shown below.

```
SELECT select_list FROM table_expression [ WHERE ... ]
[ START WITH start_expression ]
  CONNECT BY { PRIOR parent_expr = child_expr |
    child_expr = PRIOR parent_expr }
[ ORDER SIBLINGS BY column1 [ ASC | DESC ]
  [, column2 [ ASC | DESC ] ] ...
[ GROUP BY ... ]
[ HAVING ... ]
[ other ... ]
```

select_list is one or more expressions that comprise the fields of the result set. *table_expression* is one or more tables or views from which the rows of the result set originate. *other* is any additional legal `SELECT` command clauses. The clauses pertinent to hierarchical queries, `START WITH`, `CONNECT BY`, and `ORDER SIBLINGS BY` are described in the following sections.

Note: At this time, Advanced Server does not support the use of `AND` (or other operators) in the `CONNECT BY` clause.

2.2.5.1 Defining the Parent/Child Relationship

For any given row, its parent and its children are determined by the CONNECT BY clause. The CONNECT BY clause must consist of two expressions compared with the equals (=) operator. In addition, one of these two expressions must be preceded by the keyword, PRIOR.

For any given row, to determine its children:

1. Evaluate *parent_expr* on the given row
2. Evaluate *child_expr* on any other row resulting from the evaluation of *table_expression*
3. If *parent_expr* = *child_expr*, then this row is a child node of the given parent row
4. Repeat the process for all remaining rows in *table_expression*. All rows that satisfy the equation in step 3 are the children nodes of the given parent row.

Note: The evaluation process to determine if a row is a child node occurs on every row returned by *table_expression* before the WHERE clause is applied to *table_expression*.

By iteratively repeating this process treating each child node found in the prior steps as a parent, an inverted tree of nodes is constructed. The process is complete when the final set of child nodes has no children of their own - these are the leaf nodes.

A SELECT command that includes a CONNECT BY clause typically includes the START WITH clause. The START WITH clause determines the rows that are to be the root nodes - i.e., the rows that are the initial parent nodes upon which the algorithm described previously is to be applied. This is further explained in the following section.

2.2.5.2 Selecting the Root Nodes

The START WITH clause is used to determine the row(s) selected by *table_expression* that are to be used as the root nodes. All rows selected by *table_expression* where *start_expression* evaluates to true become a root node of a tree. Thus, the number of potential trees in the result set is equal to the number of root nodes. As a consequence, if the START WITH clause is omitted, then every row returned by *table_expression* is a root of its own tree.

2.2.5.3 Organization Tree in the Sample Application

Consider the `emp` table of the sample application. The rows of the `emp` table form a hierarchy based upon the `mgr` column which contains the employee number of the employee's manager. Each employee has at most, one manager. KING is the president of the company so he has no manager, therefore KING's `mgr` column is null. Also, it is

possible for an employee to act as a manager for more than one employee. This relationship forms a typical, tree-structured, hierarchical organization chart as illustrated below.

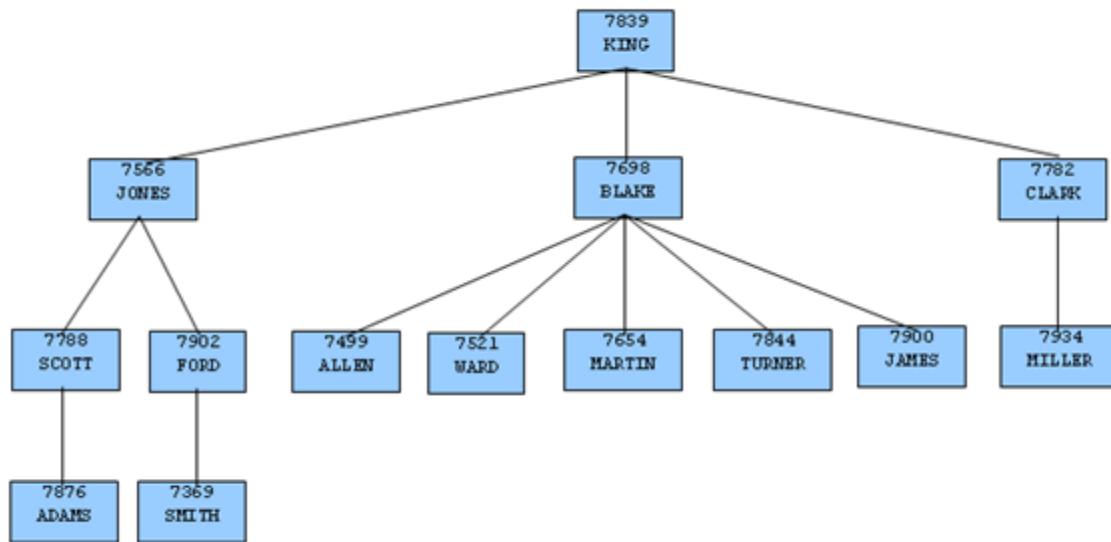


Figure 2 Employee Organization Hierarchy

To form a hierarchical query based upon this relationship, the `SELECT` command includes the clause, `CONNECT BY PRIOR empno = mgr`. For example, given the company president, KING, with employee number 7839, any employee whose `mgr` column is 7839 reports directly to KING which is true for JONES, BLAKE, and CLARK (these are the child nodes of KING). Similarly, for employee, JONES, any other employee with `mgr` column equal to 7566 is a child node of JONES - these are SCOTT and FORD in this example.

The top of the organization chart is KING so there is one root node in this tree. The `START WITH mgr IS NULL` clause selects only KING as the initial root node.

The complete `SELECT` command is shown below.

```

SELECT ename, empno, mgr
FROM emp
START WITH mgr IS NULL
CONNECT BY PRIOR empno = mgr;
  
```

The rows in the query output traverse each branch from the root to leaf moving in a top-to-bottom, left-to-right order. Below is the output from this query.

ename	empno	mgr
KING	7839	
JONES	7566	7839
SCOTT	7788	7566

ADAMS		7876		7788
FORD		7902		7566
SMITH		7369		7902
BLAKE		7698		7839
ALLEN		7499		7698
WARD		7521		7698
MARTIN		7654		7698
TURNER		7844		7698
JAMES		7900		7698
CLARK		7782		7839
MILLER		7934		7782
(14 rows)				

2.2.5.4 Node Level

LEVEL is a pseudo-column that can be used wherever a column can appear in the SELECT command. For each row in the result set, LEVEL returns a non-zero integer value designating the depth in the hierarchy of the node represented by this row. The LEVEL for root nodes is 1. The LEVEL for direct children of root nodes is 2, and so on.

The following query is a modification of the previous query with the addition of the LEVEL pseudo-column. In addition, using the LEVEL value, the employee names are indented to further emphasize the depth in the hierarchy of each row.

```
SELECT LEVEL, LPAD (' ', 2 * (LEVEL - 1)) || ename "employee", empno, mgr
FROM emp START WITH mgr IS NULL
CONNECT BY PRIOR empno = mgr;
```

The output from this query follows.

level	employee	empno	mgr
1	KING	7839	
2	JONES	7566	7839
3	SCOTT	7788	7566
4	ADAMS	7876	7788
3	FORD	7902	7566
4	SMITH	7369	7902
2	BLAKE	7698	7839
3	ALLEN	7499	7698
3	WARD	7521	7698
3	MARTIN	7654	7698
3	TURNER	7844	7698
3	JAMES	7900	7698
2	CLARK	7782	7839
3	MILLER	7934	7782
(14 rows)			

Nodes that share a common parent and are at the same level are called *siblings*. For example in the above output, employees ALLEN, WARD, MARTIN, TURNER, and JAMES are siblings since they are all at level three with parent, BLAKE. JONES, BLAKE, and CLARK are siblings since they are at level two and KING is their common parent.

2.2.5.5 Ordering the Siblings

The result set can be ordered so the siblings appear in ascending or descending order by selected column value(s) using the ORDER SIBLINGS BY clause. This is a special case of the ORDER BY clause that can be used only with hierarchical queries.

The previous query is further modified with the addition of ORDER SIBLINGS BY ename ASC.

```
SELECT LEVEL, LPAD (' ', 2 * (LEVEL - 1)) || ename "employee", empno, mgr
FROM emp START WITH mgr IS NULL
CONNECT BY PRIOR empno = mgr
ORDER SIBLINGS BY ename ASC;
```

The output from the prior query is now modified so the siblings appear in ascending order by name. Siblings BLAKE, CLARK, and JONES are now alphabetically arranged under KING. Siblings ALLEN, JAMES, MARTIN, TURNER, and WARD are alphabetically arranged under BLAKE, and so on.

level	employee	empno	mgr
1	KING	7839	
2	BLAKE	7698	7839
3	ALLEN	7499	7698
3	JAMES	7900	7698
3	MARTIN	7654	7698
3	TURNER	7844	7698
3	WARD	7521	7698
2	CLARK	7782	7839
3	MILLER	7934	7782
2	JONES	7566	7839
3	FORD	7902	7566
4	SMITH	7369	7902
3	SCOTT	7788	7566
4	ADAMS	7876	7788

(14 rows)

This final example adds the WHERE clause and starts with three root nodes. After the node tree is constructed, the WHERE clause filters out rows in the tree to form the result set.

```
SELECT LEVEL, LPAD (' ', 2 * (LEVEL - 1)) || ename "employee", empno, mgr
FROM emp WHERE mgr IN (7839, 7782, 7902, 7788)
START WITH ename IN ('BLAKE', 'CLARK', 'JONES')
CONNECT BY PRIOR empno = mgr
ORDER SIBLINGS BY ename ASC;
```

The output from the query shows three root nodes (level one) - BLAKE, CLARK, and JONES. In addition, rows that do not satisfy the WHERE clause have been eliminated from the output.

level	employee	empno	mgr
1	BLAKE	7698	7839

```

1 | CLARK      | 7782 | 7839
2 | MILLER    | 7934 | 7782
1 | JONES      | 7566 | 7839
3 | SMITH      | 7369 | 7902
3 | ADAMS      | 7876 | 7788
(6 rows)

```

2.2.5.6 Retrieving the Root Node with CONNECT_BY_ROOT

`CONNECT_BY_ROOT` is a unary operator that can be used to qualify a column in order to return the column's value of the row considered to be the rootnode in relation to the current row.

Note: A *unary operator* operates on a single operand, which in the case of `CONNECT_BY_ROOT`, is the column name following the `CONNECT_BY_ROOT` keyword.

In the context of the `SELECT` list, the `CONNECT_BY_ROOT` operator is shown by the following.

```
SELECT [... ,] CONNECT_BY_ROOT column [, ...]
      FROM table_expression ...
```

The following are some points to note about the `CONNECT_BY_ROOT` operator.

- The `CONNECT_BY_ROOT` operator can be used in the `SELECT` list, the `WHERE` clause, the `GROUP BY` clause, the `HAVING` clause, the `ORDER BY` clause, and the `ORDER SIBLINGS BY` clause as long as the `SELECT` command is for a hierarchical query.
- The `CONNECT_BY_ROOT` operator cannot be used in the `CONNECT BY` clause or the `START WITH` clause of the hierarchical query.
- It is possible to apply `CONNECT_BY_ROOT` to an expression involving a column, but to do so, the expression must be enclosed within parentheses.

The following query shows the use of the `CONNECT_BY_ROOT` operator to return the employee number and employee name of the rootnode for each employee listed in the result set based on trees starting with employees BLAKE, CLARK, and JONES.

```
SELECT LEVEL, LPAD (' ', 2 * (LEVEL - 1)) || ename "employee", empno, mgr,
CONNECT_BY_ROOT empno "mgr empno",
CONNECT_BY_ROOT ename "mgr ename"
FROM emp
START WITH ename IN ('BLAKE', 'CLARK', 'JONES')
CONNECT BY PRIOR empno = mgr
ORDER SIBLINGS BY ename ASC;
```

Note that the output from the query shows that all of the root nodes in columns `mgr empno` and `mgr ename` are one of the employees, BLAKE, CLARK, or JONES, listed in the `START WITH` clause.

level	employee	empno	mgr	mgr empno	mgr ename
1	BLAKE	7698	7839	7698	BLAKE
2	ALLEN	7499	7698	7698	BLAKE
2	JAMES	7900	7698	7698	BLAKE
2	MARTIN	7654	7698	7698	BLAKE
2	TURNER	7844	7698	7698	BLAKE
2	WARD	7521	7698	7698	BLAKE
1	CLARK	7782	7839	7782	CLARK
2	MILLER	7934	7782	7782	CLARK
1	JONES	7566	7839	7566	JONES
2	FORD	7902	7566	7566	JONES
3	SMITH	7369	7902	7566	JONES
2	SCOTT	7788	7566	7566	JONES
3	ADAMS	7876	7788	7566	JONES

(13 rows)

The following is a similar query, but producing only one tree starting with the single, top-level, employee where the `mgr` column is null.

```
SELECT LEVEL, LPAD (' ', 2 * (LEVEL - 1)) || ename "employee", empno, mgr,
CONNECT_BY_ROOT empno "mgr empno",
CONNECT_BY_ROOT ename "mgr ename"
FROM emp START WITH mgr IS NULL
CONNECT BY PRIOR empno = mgr
ORDER SIBLINGS BY ename ASC;
```

In the following output, all of the root nodes in columns `mgr empno` and `mgr ename` indicate KING as the root for this particular query.

level	employee	empno	mgr	mgr empno	mgr ename
1	KING	7839		7839	KING
2	BLAKE	7698	7839	7839	KING
3	ALLEN	7499	7698	7839	KING
3	JAMES	7900	7698	7839	KING
3	MARTIN	7654	7698	7839	KING
3	TURNER	7844	7698	7839	KING
3	WARD	7521	7698	7839	KING
2	CLARK	7782	7839	7839	KING
3	MILLER	7934	7782	7839	KING
2	JONES	7566	7839	7839	KING
3	FORD	7902	7566	7839	KING
4	SMITH	7369	7902	7839	KING
3	SCOTT	7788	7566	7839	KING
4	ADAMS	7876	7788	7839	KING

(14 rows)

By contrast, the following example omits the `START WITH` clause thereby resulting in fourteen trees.

```
SELECT LEVEL, LPAD (' ', 2 * (LEVEL - 1)) || ename "employee", empno, mgr,
CONNECT_BY_ROOT empno "mgr empno",
```

```
CONNECT_BY_ROOT ename "mgr ename"
FROM emp
CONNECT BY PRIOR empno = mgr
ORDER SIBLINGS BY ename ASC;
```

The following is the output from the query. Each node appears at least once as a root node under the `mgr empno` and `mgr ename` columns since even the leaf nodes form the top of their own trees.

level	employee	empno	mgr	mgr empno	mgr ename
1	ADAMS	7876	7788	7876	ADAMS
1	ALLEN	7499	7698	7499	ALLEN
1	BLAKE	7698	7839	7698	BLAKE
2	ALLEN	7499	7698	7698	BLAKE
2	JAMES	7900	7698	7698	BLAKE
2	MARTIN	7654	7698	7698	BLAKE
2	TURNER	7844	7698	7698	BLAKE
2	WARD	7521	7698	7698	BLAKE
1	CLARK	7782	7839	7782	CLARK
2	MILLER	7934	7782	7782	CLARK
1	FORD	7902	7566	7902	FORD
2	SMITH	7369	7902	7902	FORD
1	JAMES	7900	7698	7900	JAMES
1	JONES	7566	7839	7566	JONES
2	FORD	7902	7566	7566	JONES
3	SMITH	7369	7902	7566	JONES
2	SCOTT	7788	7566	7566	JONES
3	ADAMS	7876	7788	7566	JONES
1	KING	7839		7839	KING
2	BLAKE	7698	7839	7839	KING
3	ALLEN	7499	7698	7839	KING
3	JAMES	7900	7698	7839	KING
3	MARTIN	7654	7698	7839	KING
3	TURNER	7844	7698	7839	KING
3	WARD	7521	7698	7839	KING
2	CLARK	7782	7839	7839	KING
3	MILLER	7934	7782	7839	KING
2	JONES	7566	7839	7839	KING
3	FORD	7902	7566	7839	KING
4	SMITH	7369	7902	7839	KING
3	SCOTT	7788	7566	7839	KING
4	ADAMS	7876	7788	7839	KING
1	MARTIN	7654	7698	7654	MARTIN
1	MILLER	7934	7782	7934	MILLER
1	SCOTT	7788	7566	7788	SCOTT
2	ADAMS	7876	7788	7788	SCOTT
1	SMITH	7369	7902	7369	SMITH
1	TURNER	7844	7698	7844	TURNER
1	WARD	7521	7698	7521	WARD

(39 rows)

The following illustrates the unary operator effect of `CONNECT_BY_ROOT`. As shown in this example, when applied to an expression that is not enclosed in parentheses, the `CONNECT_BY_ROOT` operator affects only the term, `ename`, immediately following it. The subsequent concatenation of `|| 'manages' || ename` is not part of the `CONNECT_BY_ROOT` operation, hence the second occurrence of `ename` results in the

value of the currently processed row while the first occurrence of `ename` results in the value from the root node.

```
SELECT LEVEL, LPAD (' ', 2 * (LEVEL - 1)) || ename "employee", empno, mgr,
CONNECT_BY_ROOT ename || ' manages ' || ename "top mgr/employee"
FROM emp
START WITH ename IN ('BLAKE', 'CLARK', 'JONES')
CONNECT BY PRIOR empno = mgr
ORDER SIBLINGS BY ename ASC;
```

The following is the output from the query. Note the values produced under the `top mgr/employee` column.

level	employee	empno	mgr	top mgr/employee
1	BLAKE	7698	7839	BLAKE manages BLAKE
2	ALLEN	7499	7698	BLAKE manages ALLEN
2	JAMES	7900	7698	BLAKE manages JAMES
2	MARTIN	7654	7698	BLAKE manages MARTIN
2	TURNER	7844	7698	BLAKE manages TURNER
2	WARD	7521	7698	BLAKE manages WARD
1	CLARK	7782	7839	CLARK manages CLARK
2	MILLER	7934	7782	CLARK manages MILLER
1	JONES	7566	7839	JONES manages JONES
2	FORD	7902	7566	JONES manages FORD
3	SMITH	7369	7902	JONES manages SMITH
2	SCOTT	7788	7566	JONES manages SCOTT
3	ADAMS	7876	7788	JONES manages ADAMS

(13 rows)

The following example uses the `CONNECT_BY_ROOT` operator on an expression enclosed in parentheses.

```
SELECT LEVEL, LPAD (' ', 2 * (LEVEL - 1)) || ename "employee", empno, mgr,
CONNECT_BY_ROOT ('Manager ' || ename || ' is emp #' || empno)
"top mgr/empno"
FROM emp
START WITH ename IN ('BLAKE', 'CLARK', 'JONES')
CONNECT BY PRIOR empno = mgr
ORDER SIBLINGS BY ename ASC;
```

The following is the output of the query. Note that the values of both `ename` and `empno` are affected by the `CONNECT_BY_ROOT` operator and as a result, return the values from the root node as shown under the `top mgr/empno` column.

level	employee	empno	mgr	top mgr/empno
1	BLAKE	7698	7839	Manager BLAKE is emp # 7698
2	ALLEN	7499	7698	Manager BLAKE is emp # 7698
2	JAMES	7900	7698	Manager BLAKE is emp # 7698
2	MARTIN	7654	7698	Manager BLAKE is emp # 7698
2	TURNER	7844	7698	Manager BLAKE is emp # 7698
2	WARD	7521	7698	Manager BLAKE is emp # 7698
1	CLARK	7782	7839	Manager CLARK is emp # 7782
2	MILLER	7934	7782	Manager CLARK is emp # 7782
1	JONES	7566	7839	Manager JONES is emp # 7566
2	FORD	7902	7566	Manager JONES is emp # 7566

```

3 |      SMITH |  7369 | 7902 | Manager JONES is emp # 7566
2 |     SCOTT |  7788 | 7566 | Manager JONES is emp # 7566
3 |     ADAMS |  7876 | 7788 | Manager JONES is emp # 7566
(13 rows)

```

2.2.5.7 Retrieving a Path with SYS_CONNECT_BY_PATH

SYS_CONNECT_BY_PATH is a function that works within a hierarchical query to retrieve the column values of a specified column that occur between the current node and the root node. The signature of the function is:

```
SYS_CONNECT_BY_PATH (column, delimiter)
```

The function takes two arguments:

column is the name of a column that resides within a table specified in the hierarchical query that is calling the function.

delimiter is the varchar value that separates each entry in the specified column.

The following example returns a list of employee names, and their managers; if the manager has a manager, that name is appended to the result:

```

edb=# SELECT level, ename , SYS_CONNECT_BY_PATH(ename, '/') managers
  FROM emp
 CONNECT BY PRIOR empno = mgr
 START WITH mgr IS NULL
 ORDER BY level, ename, managers;

level | ename | managers
-----+-----+
 1 | KING | /KING
 2 | BLAKE | /KING/BLAKE
 2 | CLARK | /KING/CLARK
 2 | JONES | /KING/JONES
 3 | ALLEN | /KING/BLAKE/ALLEN
 3 | FORD | /KING/JONES/FORD
 3 | JAMES | /KING/BLAKE/JAMES
 3 | MARTIN | /KING/BLAKE/MARTIN
 3 | MILLER | /KING/CLARK/MILLER
 3 | SCOTT | /KING/JONES/SCOTT
 3 | TURNER | /KING/BLAKE/TURNER
 3 | WARD | /KING/BLAKE/WARD
 4 | ADAMS | /KING/JONES/SCOTT/ADAMS
 4 | SMITH | /KING/JONES/FORD/SMITH
(14 rows)

```

Within the result set:

- The `level` column displays the number of levels that the query returned.
- The `ename` column displays the employee name.
- The `managers` column contains the hierarchical list of managers.

The Advanced Server implementation of `SYS_CONNECT_BY_PATH` does not support use of:

- `SYS_CONNECT_BY_PATH` inside `CONNECT_BY_PATH`
- `SYS_CONNECT_BY_PATH` inside `SYS_CONNECT_BY_PATH`

2.2.6 Multidimensional Analysis

Multidimensional analysis refers to the process commonly used in data warehousing applications of examining data using various combinations of dimensions. *Dimensions* are categories used to classify data such as time, geography, a company's departments, product lines, and so forth. The results associated with a particular set of dimensions are called *facts*. Facts are typically figures associated with product sales, profits, volumes, counts, etc.

In order to obtain these facts according to a set of dimensions in a relational database system, SQL aggregation is typically used. *SQL aggregation* basically means data is grouped according to certain criteria (dimensions) and the result set consists of aggregates of facts such as counts, sums, and averages of the data in each group.

The `GROUP BY` clause of the SQL `SELECT` command supports the following extensions that simplify the process of producing aggregate results.

- `ROLLUP` extension
- `CUBE` extension
- `GROUPING SETS` extension

In addition, the `GROUPING` function and the `GROUPING_ID` function can be used in the `SELECT` list or the `HAVING` clause to aid with the interpretation of the results when these extensions are used.

Note: The sample `dept` and `emp` tables are used extensively in this discussion to provide usage examples. The following changes were applied to these tables to provide more informative results.

```
UPDATE dept SET loc = 'BOSTON' WHERE deptno = 20;
INSERT INTO emp (empno,ename,job,deptno) VALUES (9001,'SMITH','CLERK',40);
INSERT INTO emp (empno,ename,job,deptno) VALUES (9002,'JONES','ANALYST',40);
INSERT INTO emp (empno,ename,job,deptno) VALUES (9003,'ROGERS','MANAGER',40);
```

The following rows from a join of the `emp` and `dept` tables are used:

```
SELECT loc, dname, job, empno FROM emp e, dept d
WHERE e.deptno = d.deptno
ORDER BY 1, 2, 3, 4;
```

loc	dname	job	empno
BOSTON	OPERATIONS	ANALYST	9002
BOSTON	OPERATIONS	CLERK	9001
BOSTON	OPERATIONS	MANAGER	9003
BOSTON	RESEARCH	ANALYST	7788
BOSTON	RESEARCH	ANALYST	7902
BOSTON	RESEARCH	CLERK	7369

BOSTON	RESEARCH	CLERK	7876
BOSTON	RESEARCH	MANAGER	7566
CHICAGO	SALES	CLERK	7900
CHICAGO	SALES	MANAGER	7698
CHICAGO	SALES	SALESMAN	7499
CHICAGO	SALES	SALESMAN	7521
CHICAGO	SALES	SALESMAN	7654
CHICAGO	SALES	SALESMAN	7844
NEW YORK	ACCOUNTING	CLERK	7934
NEW YORK	ACCOUNTING	MANAGER	7782
NEW YORK	ACCOUNTING	PRESIDENT	7839

(17 rows)

The `loc`, `dname`, and `job` columns are used for the dimensions of the SQL aggregations used in the examples. The resulting facts of the aggregations are the number of employees obtained by using the `COUNT(*)` function.

A basic query grouping the `loc`, `dname`, and `job` columns is given by the following.

```
SELECT loc, dname, job, COUNT(*) AS "employees" FROM emp e, dept d
WHERE e.deptno = d.deptno
GROUP BY loc, dname, job
ORDER BY 1, 2, 3;
```

The rows of this result set using the basic `GROUP BY` clause without extensions are referred to as the *base aggregate* rows.

loc	dname	job	employees
BOSTON	OPERATIONS	ANALYST	1
BOSTON	OPERATIONS	CLERK	1
BOSTON	OPERATIONS	MANAGER	1
BOSTON	RESEARCH	ANALYST	2
BOSTON	RESEARCH	CLERK	2
BOSTON	RESEARCH	MANAGER	1
CHICAGO	SALES	CLERK	1
CHICAGO	SALES	MANAGER	1
CHICAGO	SALES	SALESMAN	4
NEW YORK	ACCOUNTING	CLERK	1
NEW YORK	ACCOUNTING	MANAGER	1
NEW YORK	ACCOUNTING	PRESIDENT	1

(12 rows)

The `ROLLUP` and `CUBE` extensions add to the base aggregate rows by providing additional levels of subtotals to the result set.

The `GROUPING SETS` extension provides the ability to combine different types of groupings into a single result set.

The `GROUPING` and `GROUPING_ID` functions aid in the interpretation of the result set.

The additions provided by these extensions are discussed in more detail in the subsequent sections.

2.2.6.1 ROLLUP Extension

The `ROLLUP` extension produces a hierarchical set of groups with subtotals for each hierarchical group as well as a grand total. The order of the hierarchy is determined by the order of the expressions given in the `ROLLUP` expression list. The top of the hierarchy is the leftmost item in the list. Each successive item proceeding to the right moves down the hierarchy with the rightmost item being the lowest level.

The syntax for a single `ROLLUP` is as follows:

```
ROLLUP ( { expr_1 | ( expr_1a [, expr_1b ] ... ) }
          [, expr_2 | ( expr_2a [, expr_2b ] ... ) ] ... )
```

Each `expr` is an expression that determines the grouping of the result set. If enclosed within parenthesis as `(expr_1a, expr_1b, ...)` then the combination of values returned by `expr_1a` and `expr_1b` defines a single grouping level of the hierarchy.

The base level of aggregates returned in the result set is for each unique combination of values returned by the expression list.

In addition, a subtotal is returned for the first item in the list (`expr_1` or the combination of `(expr_1a, expr_1b, ...)`, whichever is specified) for each unique value. A subtotal is returned for the second item in the list (`expr_2` or the combination of `(expr_2a, expr_2b, ...)`, whichever is specified) for each unique value, within each grouping of the first item and so on. Finally a grand total is returned for the entire result set.

For the subtotal rows, null is returned for the items across which the subtotal is taken.

The `ROLLUP` extension specified within the context of the `GROUP BY` clause is shown by the following:

```
SELECT select_list FROM ...
GROUP BY [...] ROLLUP ( expression_list ) [, ...]
```

The items specified in `select_list` must also appear in the `ROLLUP` `expression_list`; or they must be aggregate functions such as `COUNT`, `SUM`, `AVG`, `MIN`, or `MAX`; or they must be constants or functions whose return values are independent of the individual rows in the group (for example, the `SYSDATE` function).

The `GROUP BY` clause may specify multiple `ROLLUP` extensions as well as multiple occurrences of other `GROUP BY` extensions and individual expressions.

The `ORDER BY` clause should be used if you want the output to display in a hierarchical or other meaningful structure. There is no guarantee on the order of the result set if no `ORDER BY` clause is specified.

The number of grouping levels or totals is $n + 1$ where n represents the number of items in the `ROLLUP` expression list. A parenthesized list counts as one item.

The following query produces a rollup based on a hierarchy of columns `loc, dname, then job`.

```
SELECT loc, dname, job, COUNT(*) AS "employees" FROM emp e, dept d
WHERE e.deptno = d.deptno
GROUP BY ROLLUP (loc, dname, job)
ORDER BY 1, 2, 3;
```

The following is the result of the query. There is a count of the number of employees for each unique combination of `loc, dname, and job`, as well as subtotals for each unique combination of `loc and dname`, for each unique value of `loc`, and a grand total displayed on the last line.

loc	dname	job	employees
BOSTON	OPERATIONS	ANALYST	1
BOSTON	OPERATIONS	CLERK	1
BOSTON	OPERATIONS	MANAGER	1
BOSTON	OPERATIONS		3
BOSTON	RESEARCH	ANALYST	2
BOSTON	RESEARCH	CLERK	2
BOSTON	RESEARCH	MANAGER	1
BOSTON	RESEARCH		5
BOSTON			8
CHICAGO	SALES	CLERK	1
CHICAGO	SALES	MANAGER	1
CHICAGO	SALES	SALESMAN	4
CHICAGO	SALES		6
CHICAGO			6
NEW YORK	ACCOUNTING	CLERK	1
NEW YORK	ACCOUNTING	MANAGER	1
NEW YORK	ACCOUNTING	PRESIDENT	1
NEW YORK	ACCOUNTING		3
NEW YORK			3
			17
(20 rows)			

The following query shows the effect of combining items in the `ROLLUP` list within parenthesis.

```
SELECT loc, dname, job, COUNT(*) AS "employees" FROM emp e, dept d
WHERE e.deptno = d.deptno
GROUP BY ROLLUP (loc, (dname, job))
ORDER BY 1, 2, 3;
```

In the output, note that there are no subtotals for `loc and dname` combinations as in the prior example.

loc	dname	job	employees
BOSTON	OPERATIONS	ANALYST	1
BOSTON	OPERATIONS	CLERK	1
BOSTON	OPERATIONS	MANAGER	1
BOSTON	RESEARCH	ANALYST	2
BOSTON	RESEARCH	CLERK	2
BOSTON	RESEARCH	MANAGER	1
BOSTON			8
CHICAGO	SALES	CLERK	1
CHICAGO	SALES	MANAGER	1
CHICAGO	SALES	SALESMAN	4
CHICAGO			6
NEW YORK	ACCOUNTING	CLERK	1
NEW YORK	ACCOUNTING	MANAGER	1
NEW YORK	ACCOUNTING	PRESIDENT	1
NEW YORK			3
			17
(16 rows)			

If the first two columns in the ROLLUP list are enclosed in parenthesis, the subtotal levels differ as well.

```
SELECT loc, dname, job, COUNT(*) AS "employees" FROM emp e, dept d
WHERE e.deptno = d.deptno
GROUP BY ROLLUP ((loc, dname), job)
ORDER BY 1, 2, 3;
```

Now there is a subtotal for each unique loc and dname combination, but none for unique values of loc.

loc	dname	job	employees
BOSTON	OPERATIONS	ANALYST	1
BOSTON	OPERATIONS	CLERK	1
BOSTON	OPERATIONS	MANAGER	1
BOSTON	OPERATIONS		3
BOSTON	RESEARCH	ANALYST	2
BOSTON	RESEARCH	CLERK	2
BOSTON	RESEARCH	MANAGER	1
BOSTON	RESEARCH		5
CHICAGO	SALES	CLERK	1
CHICAGO	SALES	MANAGER	1
CHICAGO	SALES	SALESMAN	4
CHICAGO	SALES		6
NEW YORK	ACCOUNTING	CLERK	1
NEW YORK	ACCOUNTING	MANAGER	1
NEW YORK	ACCOUNTING	PRESIDENT	1
NEW YORK	ACCOUNTING		3
			17
(17 rows)			

2.2.6.2 CUBE Extension

The `CUBE` extension is similar to the `ROLLUP` extension. However, unlike `ROLLUP`, which produces groupings and results in a hierarchy based on a left to right listing of items in the `ROLLUP` expression list, a `CUBE` produces groupings and subtotals based on every permutation of all items in the `CUBE` expression list. Thus, the result set contains more rows than a `ROLLUP` performed on the same expression list.

The syntax for a single `CUBE` is as follows:

```
CUBE ( { expr_1 | ( expr_1a [, expr_1b ] ... ) }
      [, expr_2 | ( expr_2a [, expr_2b ] ... ) ] ... )
```

Each `expr` is an expression that determines the grouping of the result set. If enclosed within parenthesis as `(expr_1a, expr_1b, ...)` then the combination of values returned by `expr_1a` and `expr_1b` defines a single group.

The base level of aggregates returned in the result set is for each unique combination of values returned by the expression list.

In addition, a subtotal is returned for the first item in the list (`expr_1` or the combination of `(expr_1a, expr_1b, ...)`, whichever is specified) for each unique value. A subtotal is returned for the second item in the list (`expr_2` or the combination of `(expr_2a, expr_2b, ...)`, whichever is specified) for each unique value. A subtotal is also returned for each unique combination of the first item and the second item. Similarly, if there is a third item, a subtotal is returned for each unique value of the third item, each unique value of the third item and first item combination, each unique value of the third item and second item combination, and each unique value of the third item, second item, and first item combination. Finally a grand total is returned for the entire result set.

For the subtotal rows, null is returned for the items across which the subtotal is taken.

The `CUBE` extension specified within the context of the `GROUP BY` clause is shown by the following:

```
SELECT select_list FROM ...
GROUP BY [... ,] CUBE ( expression_list ) [, ...]
```

The items specified in `select_list` must also appear in the `CUBE expression_list`; or they must be aggregate functions such as `COUNT`, `SUM`, `AVG`, `MIN`, or `MAX`; or they must be constants or functions whose return values are independent of the individual rows in the group (for example, the `SYSDATE` function).

The `GROUP BY` clause may specify multiple `CUBE` extensions as well as multiple occurrences of other `GROUP BY` extensions and individual expressions.

The `ORDER BY` clause should be used if you want the output to display in a meaningful structure. There is no guarantee on the order of the result set if no `ORDER BY` clause is specified.

The number of grouping levels or totals is 2 raised to the power of n where n represents the number of items in the `CUBE` expression list. A parenthesized list counts as one item.

The following query produces a cube based on permutations of columns `loc`, `dname`, and `job`.

```
SELECT loc, dname, job, COUNT(*) AS "employees" FROM emp e, dept d
WHERE e.deptno = d.deptno
GROUP BY CUBE (loc, dname, job)
ORDER BY 1, 2, 3;
```

The following is the result of the query. There is a count of the number of employees for each combination of `loc`, `dname`, and `job`, as well as subtotals for each combination of `loc` and `dname`, for each combination of `loc` and `job`, for each combination of `dname` and `job`, for each unique value of `loc`, for each unique value of `dname`, for each unique value of `job`, and a grand total displayed on the last line.

loc	dname	job	employees
BOSTON	OPERATIONS	ANALYST	1
BOSTON	OPERATIONS	CLERK	1
BOSTON	OPERATIONS	MANAGER	1
BOSTON	OPERATIONS		3
BOSTON	RESEARCH	ANALYST	2
BOSTON	RESEARCH	CLERK	2
BOSTON	RESEARCH	MANAGER	1
BOSTON	RESEARCH		5
BOSTON		ANALYST	3
BOSTON		CLERK	3
BOSTON		MANAGER	2
BOSTON			8
CHICAGO	SALES	CLERK	1
CHICAGO	SALES	MANAGER	1
CHICAGO	SALES	SALESMAN	4
CHICAGO	SALES		6
CHICAGO		CLERK	1
CHICAGO		MANAGER	1
CHICAGO		SALESMAN	4
CHICAGO			6
NEW YORK	ACCOUNTING	CLERK	1
NEW YORK	ACCOUNTING	MANAGER	1
NEW YORK	ACCOUNTING	PRESIDENT	1
NEW YORK	ACCOUNTING		3
NEW YORK		CLERK	1
NEW YORK		MANAGER	1
NEW YORK		PRESIDENT	1
NEW YORK			3
	ACCOUNTING	CLERK	1

ACCOUNTING MANAGER 1
ACCOUNTING PRESIDENT 1
ACCOUNTING 3
OPERATIONS ANALYST 1
OPERATIONS CLERK 1
OPERATIONS MANAGER 1
OPERATIONS 3
RESEARCH ANALYST 2
RESEARCH CLERK 2
RESEARCH MANAGER 1
RESEARCH 5
SALES CLERK 1
SALES MANAGER 1
SALES SALESMAN 4
SALES 6
ANALYST 3
CLERK 5
MANAGER 4
PRESIDENT 1
SALESMAN 4
17
(50 rows)

The following query shows the effect of combining items in the CUBE list within parenthesis.

```
SELECT loc, dname, job, COUNT(*) AS "employees" FROM emp e, dept d
WHERE e.deptno = d.deptno
GROUP BY CUBE (loc, (dname, job))
ORDER BY 1, 2, 3;
```

In the output note that there are no subtotals for permutations involving loc and dname combinations, loc and job combinations, or for dname by itself, or for job by itself.

loc	dname	job	employees
BOSTON	OPERATIONS	ANALYST	1
BOSTON	OPERATIONS	CLERK	1
BOSTON	OPERATIONS	MANAGER	1
BOSTON	RESEARCH	ANALYST	2
BOSTON	RESEARCH	CLERK	2
BOSTON	RESEARCH	MANAGER	1
BOSTON			8
CHICAGO	SALES	CLERK	1
CHICAGO	SALES	MANAGER	1
CHICAGO	SALES	SALESMAN	4
CHICAGO			6
NEW YORK	ACCOUNTING	CLERK	1
NEW YORK	ACCOUNTING	MANAGER	1
NEW YORK	ACCOUNTING	PRESIDENT	1
NEW YORK			3
	ACCOUNTING	CLERK	1
	ACCOUNTING	MANAGER	1
	ACCOUNTING	PRESIDENT	1
	OPERATIONS	ANALYST	1
	OPERATIONS	CLERK	1
	OPERATIONS	MANAGER	1
	RESEARCH	ANALYST	2
	RESEARCH	CLERK	2
	RESEARCH	MANAGER	1

	SALES	CLERK	1
	SALES	MANAGER	1
	SALES	SALESMAN	4
			17
(28 rows)			

The following query shows another variation whereby the first expression is specified outside of the CUBE extension.

```
SELECT loc, dname, job, COUNT(*) AS "employees" FROM emp e, dept d
WHERE e.deptno = d.deptno
GROUP BY loc, CUBE (dname, job)
ORDER BY 1, 2, 3;
```

In this output, the permutations are performed for `dname` and `job` within each grouping of `loc`.

loc	dname	job	employees
BOSTON	OPERATIONS	ANALYST	1
BOSTON	OPERATIONS	CLERK	1
BOSTON	OPERATIONS	MANAGER	1
BOSTON	OPERATIONS		3
BOSTON	RESEARCH	ANALYST	2
BOSTON	RESEARCH	CLERK	2
BOSTON	RESEARCH	MANAGER	1
BOSTON	RESEARCH		5
BOSTON		ANALYST	3
BOSTON		CLERK	3
BOSTON		MANAGER	2
BOSTON			8
CHICAGO	SALES	CLERK	1
CHICAGO	SALES	MANAGER	1
CHICAGO	SALES	SALESMAN	4
CHICAGO	SALES		6
CHICAGO		CLERK	1
CHICAGO		MANAGER	1
CHICAGO		SALESMAN	4
CHICAGO			6
NEW YORK	ACCOUNTING	CLERK	1
NEW YORK	ACCOUNTING	MANAGER	1
NEW YORK	ACCOUNTING	PRESIDENT	1
NEW YORK	ACCOUNTING		3
NEW YORK		CLERK	1
NEW YORK		MANAGER	1
NEW YORK		PRESIDENT	1
NEW YORK			3
(28 rows)			

2.2.6.3 GROUPING SETS Extension

The use of the GROUPING SETS extension within the GROUP BY clause provides a means to produce one result set that is actually the concatenation of multiple results sets based upon different groupings. In other words, a UNION ALL operation is performed combining the result sets of multiple groupings into one result set.

Note that a UNION ALL operation, and therefore the GROUPING SETS extension, do not eliminate duplicate rows from the result sets that are being combined together.

The syntax for a single GROUPING SETS extension is as follows:

```
GROUPING SETS (
    { expr_1 | ( expr_1a [, expr_1b ] ... ) | 
      ROLLUP ( expr_list ) | CUBE ( expr_list )
    } [, ...] )
```

A GROUPING SETS extension can contain any combination of one or more comma-separated expressions, lists of expressions enclosed within parenthesis, ROLLUP extensions, and CUBE extensions.

The GROUPING SETS extension is specified within the context of the GROUP BY clause as shown by the following:

```
SELECT select_list FROM ...
GROUP BY [... ,] GROUPING SETS ( expression_list ) [, ...]
```

The items specified in *select_list* must also appear in the GROUPING SETS *expression_list*; or they must be aggregate functions such as COUNT, SUM, AVG, MIN, or MAX; or they must be constants or functions whose return values are independent of the individual rows in the group (for example, the SYSDATE function).

The GROUP BY clause may specify multiple GROUPING SETS extensions as well as multiple occurrences of other GROUP BY extensions and individual expressions.

The ORDER BY clause should be used if you want the output to display in a meaningful structure. There is no guarantee on the order of the result set if no ORDER BY clause is specified.

The following query produces a union of groups given by columns loc, dname, and job.

```
SELECT loc, dname, job, COUNT(*) AS "employees" FROM emp e, dept d
WHERE e.deptno = d.deptno
GROUP BY GROUPING SETS (loc, dname, job)
ORDER BY 1, 2, 3;
```

The result is as follows:

loc	dname	job	employees
BOSTON			8
CHICAGO			6
NEW YORK			3
	ACCOUNTING		3
	OPERATIONS		3
	RESEARCH		5
	SALES		6
		ANALYST	3
		CLERK	5
		MANAGER	4
		PRESIDENT	1
		SALESMAN	4
(12 rows)			

This is equivalent to the following query, which employs the use of the UNION ALL operator.

```
SELECT loc AS "loc", NULL AS "dname", NULL AS "job", COUNT(*) AS "employees"
FROM emp e, dept d
WHERE e.deptno = d.deptno
GROUP BY loc
UNION ALL
SELECT NULL, dname, NULL, COUNT(*) AS "employees" FROM emp e, dept d
WHERE e.deptno = d.deptno
GROUP BY dname
UNION ALL
SELECT NULL, NULL, job, COUNT(*) AS "employees" FROM emp e, dept d
WHERE e.deptno = d.deptno
GROUP BY job
ORDER BY 1, 2, 3;
```

The output from the UNION ALL query is the same as the GROUPING SETS output.

loc	dname	job	employees
BOSTON			8
CHICAGO			6
NEW YORK			3
	ACCOUNTING		3
	OPERATIONS		3
	RESEARCH		5
	SALES		6
		ANALYST	3
		CLERK	5
		MANAGER	4
		PRESIDENT	1
		SALESMAN	4
(12 rows)			

The following example shows how various types of GROUP BY extensions can be used together within a GROUPING SETS expression list.

```
SELECT loc, dname, job, COUNT(*) AS "employees" FROM emp e, dept d
WHERE e.deptno = d.deptno
```

```
GROUP BY GROUPING SETS (loc, ROLLUP (dname, job), CUBE (job, loc))
ORDER BY 1, 2, 3;
```

The following is the output from this query.

loc	dname	job	employees
BOSTON		ANALYST	3
BOSTON		CLERK	3
BOSTON		MANAGER	2
BOSTON			8
BOSTON			8
CHICAGO		CLERK	1
CHICAGO		MANAGER	1
CHICAGO		SALESMAN	4
CHICAGO			6
CHICAGO			6
NEW YORK		CLERK	1
NEW YORK		MANAGER	1
NEW YORK		PRESIDENT	1
NEW YORK			3
NEW YORK			3
	ACCOUNTING	CLERK	1
	ACCOUNTING	MANAGER	1
	ACCOUNTING	PRESIDENT	1
	ACCOUNTING		3
	OPERATIONS	ANALYST	1
	OPERATIONS	CLERK	1
	OPERATIONS	MANAGER	1
	OPERATIONS		3
	RESEARCH	ANALYST	2
	RESEARCH	CLERK	2
	RESEARCH	MANAGER	1
	RESEARCH		5
	SALES	CLERK	1
	SALES	MANAGER	1
	SALES	SALESMAN	4
	SALES		6
		ANALYST	3
		CLERK	5
		MANAGER	4
		PRESIDENT	1
		SALESMAN	4
			17
			17

(38 rows)

The output is basically a concatenation of the result sets that would be produced individually from `GROUP BY loc`, `GROUP BY ROLLUP (dname, job)`, and `GROUP BY CUBE (job, loc)`. These individual queries are shown by the following.

```
SELECT loc, NULL AS "dname", NULL AS "job", COUNT(*) AS "employees"
FROM emp e, dept d
WHERE e.deptno = d.deptno
GROUP BY loc
ORDER BY 1;
```

The following is the result set from the GROUP BY loc clause.

loc	dname	job	employees
BOSTON			8
CHICAGO			6
NEW YORK			3
(3 rows)			

The following query uses the GROUP BY ROLLUP (dname, job) clause.

```
SELECT NULL AS "loc", dname, job, COUNT(*) AS "employees" FROM emp e, dept d
WHERE e.deptno = d.deptno
GROUP BY ROLLUP (dname, job)
ORDER BY 2, 3;
```

The following is the result set from the GROUP BY ROLLUP (dname, job) clause.

loc	dname	job	employees
ACCOUNTING CLERK		1	
ACCOUNTING MANAGER		1	
ACCOUNTING PRESIDENT		1	
ACCOUNTING		3	
OPERATIONS ANALYST		1	
OPERATIONS CLERK		1	
OPERATIONS MANAGER		1	
OPERATIONS		3	
RESEARCH ANALYST		2	
RESEARCH CLERK		2	
RESEARCH MANAGER		1	
RESEARCH		5	
SALES CLERK		1	
SALES MANAGER		1	
SALES SALESMAN		4	
SALES		6	
			17
(17 rows)			

The following query uses the GROUP BY CUBE (job, loc) clause.

```
SELECT loc, NULL AS "dname", job, COUNT(*) AS "employees" FROM emp e, dept d
WHERE e.deptno = d.deptno
GROUP BY CUBE (job, loc)
ORDER BY 1, 3;
```

The following is the result set from the GROUP BY CUBE (job, loc) clause.

loc	dname	job	employees
BOSTON		ANALYST	3
BOSTON		CLERK	3
BOSTON		MANAGER	2
BOSTON			8
CHICAGO		CLERK	1
CHICAGO		MANAGER	1
CHICAGO		SALESMAN	4
CHICAGO			6

NEW YORK	CLERK	1
NEW YORK	MANAGER	1
NEW YORK	PRESIDENT	1
NEW YORK	ANALYST	3
	CLERK	5
	MANAGER	4
	PRESIDENT	1
	SALESMAN	4
		17
(18 rows)		

If the previous three queries are combined with the UNION ALL operator, a concatenation of the three results sets is produced.

```
SELECT loc AS "loc", NULL AS "dname", NULL AS "job", COUNT(*) AS "employees"
FROM emp e, dept d
WHERE e.deptno = d.deptno
GROUP BY loc
    UNION ALL
SELECT NULL, dname, job, count(*) AS "employees" FROM emp e, dept d
WHERE e.deptno = d.deptno
GROUP BY ROLLUP (dname, job)
    UNION ALL
SELECT loc, NULL, job, count(*) AS "employees" FROM emp e, dept d
WHERE e.deptno = d.deptno
GROUP BY CUBE (job, loc)
ORDER BY 1, 2, 3;
```

The following is the output, which is the same as when the GROUP BY GROUPING SETS (loc, ROLLUP (dname, job), CUBE (job, loc)) clause is used.

loc	dname	job	employees
BOSTON	ANALYST	3	
BOSTON	CLERK	3	
BOSTON	MANAGER	2	
BOSTON		8	
BOSTON		8	
CHICAGO	CLERK	1	
CHICAGO	MANAGER	1	
CHICAGO	SALESMAN	4	
CHICAGO		6	
CHICAGO		6	
NEW YORK	CLERK	1	
NEW YORK	MANAGER	1	
NEW YORK	PRESIDENT	1	
NEW YORK		3	
NEW YORK		3	
ACCOUNTING	CLERK	1	
ACCOUNTING	MANAGER	1	
ACCOUNTING	PRESIDENT	1	
ACCOUNTING		3	
OPERATIONS	ANALYST	1	
OPERATIONS	CLERK	1	
OPERATIONS	MANAGER	1	
OPERATIONS		3	
RESEARCH	ANALYST	2	
RESEARCH	CLERK	2	
RESEARCH	MANAGER	1	

Database Compatibility for Oracle® Developers Guide

RESEARCH		5
SALES	CLERK	1
SALES	MANAGER	1
SALES	SALESMAN	4
SALES		6
	ANALYST	3
	CLERK	5
	MANAGER	4
	PRESIDENT	1
	SALESMAN	4
		17
		17

(38 rows)

2.2.6.4 GROUPING Function

When using the ROLLUP, CUBE, or GROUPING SETS extensions to the GROUP BY clause, it may sometimes be difficult to differentiate between the various levels of subtotals generated by the extensions as well as the base aggregate rows in the result set. The GROUPING function provides a means of making this distinction.

The general syntax for use of the GROUPING function is shown by the following.

```
SELECT [ expr ... ] GROUPING( col_expr ) [, expr ] ...
FROM ...
GROUP BY [ ... ]
{ ROLLUP | CUBE | GROUPING SETS } ( [ ... ] col_expr
[, ...] ) [, ...]
```

The GROUPING function takes a single parameter that must be an expression of a dimension column specified in the expression list of a ROLLUP, CUBE, or GROUPING SETS extension of the GROUP BY clause.

The return value of the GROUPING function is either a 0 or 1. In the result set of a query, if the column expression specified in the GROUPING function is null because the row represents a subtotal over multiple values of that column then the GROUPING function returns a value of 1. If the row returns results based on a particular value of the column specified in the GROUPING function, then the GROUPING function returns a value of 0. In the latter case, the column can be null as well as non-null, but in any case, it is for a particular value of that column, not a subtotal across multiple values.

The following query shows how the return values of the GROUPING function correspond to the subtotal lines.

```
SELECT loc, dname, job, COUNT(*) AS "employees",
       GROUPING(loc) AS "gf_loc",
       GROUPING(dname) AS "gf_dname",
       GROUPING(job) AS "gf_job"
  FROM emp e, dept d
 WHERE e.deptno = d.deptno
 GROUP BY ROLLUP (loc, dname, job)
 ORDER BY 1, 2, 3;
```

In the three right-most columns displaying the output of the GROUPING functions, a value of 1 appears on a subtotal line wherever a subtotal is taken across values of the corresponding columns.

loc	dname	job	employees	gf_loc	gf_dname	gf_job
BOSTON	OPERATIONS	ANALYST	1	0	0	0
BOSTON	OPERATIONS	CLERK	1	0	0	0
BOSTON	OPERATIONS	MANAGER	1	0	0	0

BOSTON	OPERATIONS		3	0	0	1
BOSTON	RESEARCH	ANALYST	2	0	0	0
BOSTON	RESEARCH	CLERK	2	0	0	0
BOSTON	RESEARCH	MANAGER	1	0	0	0
BOSTON	RESEARCH		5	0	0	1
BOSTON			8	0	1	1
CHICAGO	SALES	CLERK	1	0	0	0
CHICAGO	SALES	MANAGER	1	0	0	0
CHICAGO	SALES	SALESMAN	4	0	0	0
CHICAGO	SALES		6	0	0	1
CHICAGO			6	0	1	1
NEW YORK	ACCOUNTING	CLERK	1	0	0	0
NEW YORK	ACCOUNTING	MANAGER	1	0	0	0
NEW YORK	ACCOUNTING	PRESIDENT	1	0	0	0
NEW YORK	ACCOUNTING		3	0	0	1
NEW YORK			3	0	1	1
			17	1	1	1

(20 rows)

These indicators can be used as screening criteria for particular subtotals. For example, using the previous query, you can display only those subtotals for `loc` and `dname` combinations by using the `GROUPING` function in a `HAVING` clause.

```
SELECT loc, dname, job, COUNT(*) AS "employees",
       GROUPING(loc) AS "gf_loc",
       GROUPING(dname) AS "gf_dname",
       GROUPING(job) AS "gf_job"
  FROM emp e, dept d
 WHERE e.deptno = d.deptno
 GROUP BY ROLLUP (loc, dname, job)
 HAVING GROUPING(loc) = 0
    AND GROUPING(dname) = 0
    AND GROUPING(job) = 1
 ORDER BY 1, 2;
```

This query produces the following result:

loc	dname	job	employees	gf_loc	gf_dname	gf_job
BOSTON	OPERATIONS		3	0	0	1
BOSTON	RESEARCH		5	0	0	1
CHICAGO	SALES		6	0	0	1
NEW YORK	ACCOUNTING		3	0	0	1

(4 rows)

The `GROUPING` function can be used to distinguish a subtotal row from a base aggregate row or from certain subtotal rows where one of the items in the expression list returns null as a result of the column on which the expression is based being null for one or more rows in the table, as opposed to representing a subtotal over the column.

To illustrate this point, the following row is added to the `emp` table. This provides a row with a null value for the `job` column.

```
INSERT INTO emp (empno,ename,deptno) VALUES (9004,'PETERS',40);
```

The following query is issued using a reduced number of rows for clarity.

```
SELECT loc, job, COUNT(*) AS "employees",
       GROUPING(loc) AS "gf_loc",
       GROUPING(job) AS "gf_job"
  FROM emp e, dept d
 WHERE e.deptno = d.deptno AND loc = 'BOSTON'
 GROUP BY CUBE (loc, job)
 ORDER BY 1, 2;
```

Note that the output contains two rows containing BOSTON in the loc column and spaces in the job column (fourth and fifth entries in the table).

loc	job	employees	gf_loc	gf_job
BOSTON	ANALYST	3	0	0
BOSTON	CLERK	3	0	0
BOSTON	MANAGER	2	0	0
BOSTON		1	0	0
BOSTON		9	0	1
	ANALYST	3	1	0
	CLERK	3	1	0
	MANAGER	2	1	0
		1	1	0
		9	1	1

(10 rows)

The fifth row where the GROUPING function on the job column (gf_job) returns 1 indicates this is a subtotal over all jobs. Note that the row contains a subtotal value of 9 in the employees column.

The fourth row where the GROUPING function on the job column as well as on the loc column returns 0 indicates this is a base aggregate of all rows where loc is BOSTON and job is null, which is the row inserted for this example. The employees column contains 1, which is the count of the single such row inserted.

Also note that in the ninth row (next to last) the GROUPING function on the job column returns 0 while the GROUPING function on the loc column returns 1 indicating this is a subtotal over all locations where the job column is null, which again, is a count of the single row inserted for this example.

2.2.6.5 GROUPING_ID Function

The GROUPING_ID function provides a simplification of the GROUPING function in order to determine the subtotal level of a row in the result set from a ROLLBACK, CUBE, or GROUPING SETS extension.

The GROUPING function takes only one column expression and returns an indication of whether or not a row is a subtotal over all values of the given column. Thus, multiple GROUPING functions may be required to interpret the level of subtotals for queries with multiple grouping columns.

The GROUPING_ID function accepts one or more column expressions that have been used in the ROLLBACK, CUBE, or GROUPING SETS extensions and returns a single integer that can be used to determine over which of these columns a subtotal has been aggregated.

The general syntax for use of the GROUPING_ID function is shown by the following.

```
SELECT [ expr ... ]
    GROUPING_ID( col_expr_1 [, col_expr_2 ] ... )
    [, expr ] ...
FROM ...
GROUP BY [ ... ]
{ ROLLUP | CUBE | GROUPING SETS } ( [ ... ] col_expr_1
    [, col_expr_2 ] [ , ... ] ) [, ... ]
```

The GROUPING_ID function takes one or more parameters that must be expressions of dimension columns specified in the expression list of a ROLLUP, CUBE, or GROUPING SETS extension of the GROUP BY clause.

The GROUPING_ID function returns an integer value. This value corresponds to the base-10 interpretation of a bit vector consisting of the concatenated 1's and 0's that would be returned by a series of GROUPING functions specified in the same left-to-right order as the ordering of the parameters specified in the GROUPING_ID function.

The following query shows how the returned values of the GROUPING_ID function represented in column gid correspond to the values returned by two GROUPING functions on columns loc and dname.

```
SELECT loc, dname, COUNT(*) AS "employees",
    GROUPING(loc) AS "gf_loc", GROUPING(dname) AS "gf_dname",
    GROUPING_ID(loc, dname) AS "gid"
FROM emp e, dept d
WHERE e.deptno = d.deptno
GROUP BY CUBE (loc, dname)
ORDER BY 6, 1, 2;
```

In the following output, note the relationship between a bit vector consisting of the `gf_loc` value and `gf_dname` value compared to the integer given in `gid`.

loc	dname	employees	gf_loc	gf_dname	gid
BOSTON	OPERATIONS	3	0	0	0
BOSTON	RESEARCH	5	0	0	0
CHICAGO	SALES	6	0	0	0
NEW YORK	ACCOUNTING	3	0	0	0
BOSTON		8	0	1	1
CHICAGO		6	0	1	1
NEW YORK		3	0	1	1
	ACCOUNTING	3	1	0	2
	OPERATIONS	3	1	0	2
	RESEARCH	5	1	0	2
	SALES	6	1	0	2
		17	1	1	3
(12 rows)					

The following table provides specific examples of the `GROUPING_ID` function calculations based on the `GROUPING` function return values for four rows of the output.

loc	dname	Bit Vector gf_loc	Bit Vector gf_dname	GROUPING_ID gid
BOSTON	OPERATIONS	0 * 2 ¹ + 0 * 2 ⁰		0
BOSTON	null	0 * 2 ¹ + 1 * 2 ⁰		1
null	ACCOUNTING	1 * 2 ¹ + 0 * 2 ⁰		2
null	null	1 * 2 ¹ + 1 * 2 ⁰		3

The following table summarizes how the `GROUPING_ID` function return values correspond to the grouping columns over which aggregation occurs.

Aggregation by Column	Bit Vector gf_loc gf_dname	GROUPING_ID gid
loc, dname	0 0	0
loc	0 1	1
dname	1 0	2
Grand Total	1 1	3

So to display only those subtotals by `dname`, the following simplified query can be used with a `HAVING` clause based on the `GROUPING_ID` function.

```

SELECT loc, dname, COUNT(*) AS "employees",
       GROUPING(loc) AS "gf_loc", GROUPING(dname) AS "gf_dname",
       GROUPING_ID(loc, dname) AS "gid"
  FROM emp e, dept d
 WHERE e.deptno = d.deptno
 GROUP BY CUBE (loc, dname)
 HAVING GROUPING_ID(loc, dname) = 2
 ORDER BY 6, 1, 2;

```

The following is the result of the query.

loc	dname	employees	gf_loc	gf_dname	gid
	ACCOUNTING	3	1	0	2
	OPERATIONS	3	1	0	2
	RESEARCH	5	1	0	2
	SALES	6	1	0	2

(4 rows)

2.3 Profile Management

Advanced Server allows a database superuser to create named *profiles*. Each profile defines rules for password management that augment `password` and `md5` authentication. The rules in a profile can:

- count failed login attempts
- lock an account due to excessive failed login attempts
- mark a password for expiration
- define a grace period after a password expiration
- define rules for password complexity
- define rules that limit password re-use

A profile is a named set of password attributes that allow you to easily manage a group of roles that share comparable authentication requirements. If the password requirements change, you can modify the profile to have the new requirements applied to each user that is associated with that profile.

After creating the profile, you can associate the profile with one or more users. When a user connects to the server, the server enforces the profile that is associated with their login role. Profiles are shared by all databases within a cluster, but each cluster may have multiple profiles. A single user with access to multiple databases will use the same profile when connecting to each database within the cluster.

Advanced Server creates a profile named `default` that is associated with a new role when the role is created unless an alternate profile is specified. If you upgrade to Advanced Server from a previous server version, existing roles will automatically be assigned to the `default` profile. You cannot delete the `default` profile.

The `default` profile specifies the following attributes:

<code>FAILED_LOGIN_ATTEMPTS</code>	<code>UNLIMITED</code>
<code>PASSWORD_LOCK_TIME</code>	<code>UNLIMITED</code>
<code>PASSWORD_LIFE_TIME</code>	<code>UNLIMITED</code>
<code>PASSWORD_GRACE_TIME</code>	<code>UNLIMITED</code>
<code>PASSWORD_REUSE_TIME</code>	<code>UNLIMITED</code>
<code>PASSWORD_REUSE_MAX</code>	<code>UNLIMITED</code>
<code>PASSWORD_VERIFY_FUNCTION</code>	<code>NULL</code>

A database superuser can use the `ALTER PROFILE` command to modify the values specified by the `default` profile. For more information about modifying a profile, see Section [2.3.2](#).

2.3.1 Creating a New Profile

Use the `CREATE PROFILE` command to create a new profile. The syntax is:

```
CREATE PROFILE profile_name
    [LIMIT {parameter value} ...];
```

Include the `LIMIT` clause and one or more space-delimited *parameter/value* pairs to specify the rules enforced by Advanced Server.

Parameters:

profile_name specifies the name of the profile.

parameter specifies the attribute limited by the profile.

value specifies the parameter limit.

Advanced Server supports the *value* shown below for each *parameter*:

`FAILED_LOGIN_ATTEMPTS` specifies the number of failed login attempts that a user may make before the server locks the user out of their account for the length of time specified by `PASSWORD_LOCK_TIME`. Supported values are:

- An `INTEGER` value greater than 0.
- `DEFAULT` - the value of `FAILED_LOGIN_ATTEMPTS` specified in the `DEFAULT` profile.
- `UNLIMITED` – the connecting user may make an unlimited number of failed login attempts.

`PASSWORD_LOCK_TIME` specifies the length of time that must pass before the server unlocks an account that has been locked because of `FAILED_LOGIN_ATTEMPTS`. Supported values are:

- A `NUMERIC` value greater than or equal to 0. To specify a fractional portion of a day, specify a decimal value. For example, use the value `4.5` to specify 4 days, 12 hours.
- `DEFAULT` - the value of `PASSWORD_LOCK_TIME` specified in the `DEFAULT` profile.
- `UNLIMITED` – the account is locked until it is manually unlocked by a database superuser.

`PASSWORD_LIFE_TIME` specifies the number of days that the current password may be used before the user is prompted to provide a new password. Include the `PASSWORD_GRACE_TIME` clause when using the `PASSWORD_LIFE_TIME` clause to specify the number of days that will pass after the password expires before connections by the role are rejected. If `PASSWORD_GRACE_TIME` is not specified, the password will expire on the day specified by the default value of `PASSWORD_GRACE_TIME`, and the user will not be allowed to execute any command until a new password is provided. Supported values are:

- A `NUMERIC` value greater than or equal to 0. To specify a fractional portion of a day, specify a decimal value. For example, use the value `4 . 5` to specify 4 days, 12 hours.
- `DEFAULT` - the value of `PASSWORD_LIFE_TIME` specified in the `DEFAULT` profile.
- `UNLIMITED` – The password does not have an expiration date.

`PASSWORD_GRACE_TIME` specifies the length of the grace period after a password expires until the user is forced to change their password. When the grace period expires, a user will be allowed to connect, but will not be allowed to execute any command until they update their expired password. Supported values are:

- A `NUMERIC` value greater than or equal to 0. To specify a fractional portion of a day, specify a decimal value. For example, use the value `4 . 5` to specify 4 days, 12 hours.
- `DEFAULT` - the value of `PASSWORD_GRACE_TIME` specified in the `DEFAULT` profile.
- `UNLIMITED` – The grace period is infinite.

`PASSWORD_REUSE_TIME` specifies the number of days a user must wait before re-using a password. The `PASSWORD_REUSE_TIME` and `PASSWORD_REUSE_MAX` parameters are intended to be used together. If you specify a finite value for one of these parameters while the other is `UNLIMITED`, old passwords can never be reused. If both parameters are set to `UNLIMITED` there are no restrictions on password reuse. Supported values are:

- A `NUMERIC` value greater than or equal to 0. To specify a fractional portion of a day, specify a decimal value. For example, use the value `4 . 5` to specify 4 days, 12 hours.
- `DEFAULT` - the value of `PASSWORD_REUSE_TIME` specified in the `DEFAULT` profile.
- `UNLIMITED` – The password can be re-used without restrictions.

`PASSWORD_REUSE_MAX` specifies the number of password changes that must occur before a password can be reused. The `PASSWORD_REUSE_TIME` and

`PASSWORD_REUSE_MAX` parameters are intended to be used together. If you specify a finite value for one of these parameters while the other is `UNLIMITED`, old passwords can never be reused. If both parameters are set to `UNLIMITED` there are no restrictions on password reuse. Supported values are:

- An `INTEGER` value greater than or equal to 0.
- `DEFAULT` - the value of `PASSWORD_REUSE_MAX` specified in the `DEFAULT` profile.
- `UNLIMITED` – The password can be re-used without restrictions.

`PASSWORD_VERIFY_FUNCTION` specifies password complexity. Supported values are:

- The name of a PL/SQL function.
- `DEFAULT` - the value of `PASSWORD_VERIFY_FUNCTION` specified in the `DEFAULT` profile.
- `NULL`

Notes

Use `DROP PROFILE` command to remove the profile.

Examples

The following command creates a profile named `acctg`. The profile specifies that if a user has not authenticated with the correct password in five attempts, the account will be locked for one day:

```
CREATE PROFILE acctg LIMIT
    FAILED_LOGIN_ATTEMPTS 5
    PASSWORD_LOCK_TIME 1;
```

The following command creates a profile named `sales`. The profile specifies that a user must change their password every 90 days:

```
CREATE PROFILE sales LIMIT
    PASSWORD_LIFE_TIME 90
    PASSWORD_GRACE_TIME 3;
```

If the user has not changed their password before the 90 days specified in the profile has passed, they will be issued a warning at login. After a grace period of 3 days, their account will not be allowed to invoke any commands until they change their password.

The following command creates a profile named `acct5`. The profile specifies that a user cannot re-use a password within 180 days of the last use of the password, and must change their password at least 5 times before re-using the password:

```
CREATE PROFILE accts LIMIT
  PASSWORD_REUSE_TIME 180
  PASSWORD_REUSE_MAX 5;
```

The following command creates a profile named `resources`; the profile calls a user-defined function named `password_rules` that will verify that the password provided meets their standards for complexity:

```
CREATE PROFILE resources LIMIT
  PASSWORD_VERIFY_FUNCTION password_rules;
```

2.3.1.1 Creating a Password Function

When specifying `PASSWORD_VERIFY_FUNCTION`, you can provide a customized function that specifies the security rules that will be applied when your users change their password. For example, you can specify rules that stipulate that the new password must be at least *n* characters long, and may not contain a specific value.

The password function has the following signature:

```
function_name (user_name VARCHAR2,
               new_password VARCHAR2,
               old_password VARCHAR2) RETURN boolean
```

Where:

`user_name` is the name of the user.

`new_password` is the new password.

`old_password` is the user's previous password. If you reference this parameter within your function:

- When a database superuser changes their password, the third parameter will always be `NULL`.

- When a user with the `CREATEROLE` attribute changes their password, the parameter will pass the previous password if the statement includes the `REPLACE` clause. Note that the `REPLACE` clause is optional syntax for a user with the `CREATEROLE` privilege.

- When a user that is not a database superuser and does not have the `CREATEROLE` attribute changes their password, the third parameter will contain the previous password for the role.

The function returns a Boolean value. If the function returns true and does not raise an exception, the password is accepted; if the function returns false or raises an exception, the password is rejected. If the function raises an exception, the specified error message is displayed to the user. If the function does not raise an exception, but returns false, the following error message is displayed:

```
ERROR: password verification for the specified password failed
```

The function must be owned by a database superuser, and reside in the `sys` schema.

Example:

The following example creates a profile and a custom function; then, the function is associated with the profile. The following `CREATE PROFILE` command creates a profile named `acctg_pwd_profile`:

```
CREATE PROFILE acctg_pwd_profile;
```

The following commands create a (schema-qualified) function named `verify_password`:

```
CREATE OR REPLACE FUNCTION sys.verify_password(user_name varchar2,
new_password varchar2, old_password varchar2)
RETURN boolean IMMUTABLE
IS
BEGIN
    IF (length(new_password) < 5)
    THEN
        raise_application_error(-20001, 'too short');
    END IF;

    IF substring(new_password FROM old_password) IS NOT NULL
    THEN
        raise_application_error(-20002, 'includes old password');
    END IF;

    RETURN true;
END;
```

The function first ensures that the password is at least 5 characters long, and then compares the new password to the old password. If the new password contains fewer than 5 characters, or contains the old password, the function raises an error.

The following statement sets the ownership of the `verify_password` function to the `enterprisedb` database superuser:

```
ALTER FUNCTION verify_password(varchar2, varchar2, varchar2) OWNER TO
enterprisedb;
```

Then, the `verify_password` function is associated with the profile:

```
ALTER PROFILE acctg_pwd_profile LIMIT PASSWORD_VERIFY_FUNCTION
verify_password;
```

The following statements confirm that the function is working by first creating a test user (`alice`), and then attempting to associate invalid and valid passwords with her role:

```
CREATE ROLE alice WITH LOGIN PASSWORD 'temp_password' PROFILE
acctg_pwd_profile;
```

Then, when `alice` connects to the database and attempts to change her password, she must adhere to the rules established by the profile function. A non-superuser without `CREATEROLE` must include the `REPLACE` clause when changing a password:

```
edb=> ALTER ROLE alice PASSWORD 'hey';
ERROR: missing REPLACE clause
```

The new password must be at least 5 characters long:

```
edb=> ALTER USER alice PASSWORD 'hey' REPLACE 'temp_password';
ERROR: EDB-20001: too short
CONTEXT: edb-spl function verify_password(character varying,character
varying,character varying) line 5 at procedure/function invocation statement
```

If the new password is acceptable, the command completes without error:

```
edb=> ALTER USER alice PASSWORD 'hello' REPLACE 'temp_password';
ALTER ROLE
```

If `alice` decides to change her password, the new password must not contain the old password:

```
edb=> ALTER USER alice PASSWORD 'helloworld' REPLACE 'hello';
ERROR: EDB-20002: includes old password
CONTEXT: edb-spl function verify_password(character varying,character
varying,character varying) line 10 at procedure/function invocation statement
```

To remove the `verify` function, set `password_verify_function` to `NULL`:

```
ALTER PROFILE acctg_pwd_profile LIMIT password_verify_function NULL;
```

Then, all password constraints will be lifted:

```
edb=# ALTER ROLE alice PASSWORD 'hey';
ALTER ROLE
```

2.3.2 Altering a Profile

Use the `ALTER PROFILE` command to modify a user-defined profile; Advanced Server supports two forms of the command:

```
ALTER PROFILE profile_name RENAME TO new_name;  
  
ALTER PROFILE profile_name  
    LIMIT {parameter value} [...] ;
```

Include the `LIMIT` clause and one or more space-delimited *parameter/value* pairs to specify the rules enforced by Advanced Server, or use `ALTER PROFILE...RENAME TO` to change the name of a profile.

Parameters:

profile_name specifies the name of the profile.

new_name specifies the new name of the profile.

parameter specifies the attribute limited by the profile.

value specifies the parameter limit.

See the table in Section [2.3.1](#) for a complete list of accepted parameter/value pairs.

Examples

The following example modifies a profile named `acctg_profile`:

```
ALTER PROFILE acctg_profile  
    LIMIT FAILED_LOGIN_ATTEMPTS 3 PASSWORD_LOCK_TIME 1;
```

`acctg_profile` will count failed connection attempts when a login role attempts to connect to the server. The profile specifies that if a user has not authenticated with the correct password in three attempts, the account will be locked for one day.

The following example changes the name of `acctg_profile` to `payables_profile`:

```
ALTER PROFILE acctg_profile RENAME TO payables_profile;
```

2.3.3 Dropping a Profile

Use the `DROP PROFILE` command to drop a profile. The syntax is:

```
DROP PROFILE [IF EXISTS] profile_name [CASCADE | RESTRICT];
```

Include the `IF EXISTS` clause to instruct the server to not throw an error if the specified profile does not exist. The server will issue a notice if the profile does not exist.

Include the optional `CASCADE` clause to reassign any users that are currently associated with the profile to the `default` profile, and then drop the profile. Include the optional `RESTRICT` clause to instruct the server to not drop any profile that is associated with a role. This is the default behavior.

Parameters

profile_name

The name of the profile being dropped.

Examples

The following example drops a profile named `acctg_profile`:

```
DROP PROFILE acctg_profile CASCADE;
```

The command first re-associates any roles associated with the `acctg_profile` profile with the `default` profile, and then drops the `acctg_profile` profile.

The following example drops a profile named `acctg_profile`:

```
DROP PROFILE acctg_profile RESTRICT;
```

The `RESTRICT` clause in the command instructs the server to not drop `acctg_profile` if there are any roles associated with the profile.

2.3.4 Associating a Profile with an Existing Role

After creating a profile, you can use the ALTER USER... PROFILE or ALTER ROLE... PROFILE command to associate the profile with a role. The command syntaxrelated to profile management functionality is:

```
ALTER USER|ROLE name [ [WITH] option[...]
```

where *option* can be the following compatible clauses:

```
PROFILE profile_name
| ACCOUNT {LOCK|UNLOCK}
| PASSWORD EXPIRE [AT 'timestamp']
```

or *option* can be the following non-compatible clauses:

```
| PASSWORD SET AT 'timestamp'
| LOCK TIME 'timestamp'
| STORE PRIOR PASSWORD {'password' 'timestamp} [, ...]
```

For information about the administrative clauses of the ALTER USER or ALTER ROLE command that are supported by Advanced Server, please see the PostgreSQL core documentation available at:

<https://www.postgresql.org/docs/10/static/sql-commands.html>

Only a database superuser can use the ALTER USER|ROLE clauses that enforce profile management. The clauses enforce the following behaviors:

Include the PROFILE clause and a *profile_name* to associate a pre-defined profile with a role, or to change which pre-defined profile is associated with a user.

Include the ACCOUNT clause and the LOCK or UNLOCK keyword to specify that the user account should be placed in a locked or unlocked state.

Include the LOCK TIME '*timestamp*' clause and a date/time value to lock the role at the specified time, and unlock the role at the time indicated by the PASSWORD_LOCK_TIME parameter of the profile assigned to this role. If LOCK TIME is used with the ACCOUNT LOCK clause, the role can only be unlocked by a database superuser with the ACCOUNT UNLOCK clause.

Include the `PASSWORD EXPIRE` clause with the `AT 'timestamp'` keywords to specify a date/time when the password associated with the role will expire. If you omit the `AT 'timestamp'` keywords, the password will expire immediately.

Include the `PASSWORD SET AT 'timestamp'` keywords to set the password modification date to the time specified.

Include the `STORE PRIOR PASSWORD { 'password' 'timestamp' [, ...]}` clause to modify the password history, adding the new password and the time the password was set.

Each login role may only have one profile. To discover the profile that is currently associated with a login role, query the `profile` column of the `DBA_USERS` view.

Parameters

name

The name of the role with which the specified profile will be associated.

password

The password associated with the role.

profile_name

The name of the profile that will be associated with the role.

timestamp

The date and time at which the clause will be enforced. When specifying a value for *timestamp*, enclose the value in single-quotes.

Examples

The following command uses the `ALTER USER... PROFILE` command to associate a profile named `acctg` with a user named `john`:

```
ALTER USER john PROFILE acctg_profile;
```

The following command uses the `ALTER ROLE... PROFILE` command to associate a profile named `acctg` with a user named `john`:

```
ALTER ROLE john PROFILE acctg_profile;
```

2.3.5 Unlocking a Locked Account

A database superuser can use clauses of the `ALTER USER | ROLE...` command to lock or unlock a role. The syntax is:

```
ALTER USER | ROLE name
    ACCOUNT {LOCK|UNLOCK}
    LOCK TIME 'timestamp'
```

Include the `ACCOUNT LOCK` clause to lock a role immediately; when locked, a role's `LOGIN` functionality is disabled. When you specify the `ACCOUNT LOCK` clause without the `LOCK TIME` clause, the state of the role will not change until a superuser uses the `ACCOUNT UNLOCK` clause to unlock the role.

Use the `ACCOUNT UNLOCK` clause to unlock a role.

Use the `LOCK TIME 'timestamp'` clause to instruct the server to lock the account at the time specified by the given timestamp for the length of time specified by the `PASSWORD_LOCK_TIME` parameter of the profile associated with this role.

Combine the `LOCK TIME 'timestamp'` clause and the `ACCOUNT LOCK` clause to lock an account at a specified time until the account is unlocked by a superuser invoking the `ACCOUNT UNLOCK` clause.

Parameters

name

The name of the role that is being locked or unlocked.

timestamp

The date and time at which the role will be locked. When specifying a value for *timestamp*, enclose the value in single-quotes.

Note

This command (available only in Advanced Server) is implemented to support Oracle-styled profile management.

Examples

The following example uses the ACCOUNT LOCK clause to lock the role named `john`. The account will remain locked until the account is unlocked with the ACCOUNT UNLOCK clause:

```
ALTER ROLE john ACCOUNT LOCK;
```

The following example uses the ACCOUNT UNLOCK clause to unlock the role named `john`:

```
ALTER USER john ACCOUNT UNLOCK;
```

The following example uses the LOCK TIME '*timestamp*' clause to lock the role named `john` on September 4, 2015:

```
ALTER ROLE john LOCK TIME 'September 4 12:00:00 2015' ;
```

The role will remain locked for the length of time specified by the `PASSWORD_LOCK_TIME` parameter.

The following example combines the LOCK TIME '*timestamp*' clause and the ACCOUNT LOCK clause to lock the role named `john` on September 4, 2015:

```
ALTER ROLE john LOCK TIME 'September 4 12:00:00 2015' ACCOUNT LOCK;
```

The role will remain locked until a database superuser uses the ACCOUNT UNLOCK command to unlock the role.

2.3.6 Creating a New Role Associated with a Profile

A database superuser can use clauses of the `CREATE USER|ROLE` command to assign a named profile to a role when creating the role, or to specify profile management details for a role. The command syntaxrelated to profile management functionality is:

```
CREATE USER|ROLE name [ [WITH] option [...] ]
```

where *option* can be the following compatible clauses:

```
PROFILE profile_name
| ACCOUNT {LOCK|UNLOCK}
| PASSWORD EXPIRE [AT 'timestamp']
```

or *option* can be the following non-compatible clauses:

```
| LOCK TIME 'timestamp'
```

For information about the administrative clauses of the `CREATE USER` or `CREATE ROLE` command that are supported by Advanced Server, please see the PostgreSQL core documentation available at:

<https://www.postgresql.org/docs/10/static/sql-commands.html>

`CREATE ROLE|USER... PROFILE` adds a new role with an associated profile to an Advanced Server database cluster.

Roles created with the `CREATE USER` command are (by default) login roles. Roles created with the `CREATE ROLE` command are (by default) not login roles. To create a login account with the `CREATE ROLE` command, you must include the `LOGIN` keyword.

Only a database superuser can use the `CREATE USER|ROLE` clauses that enforce profile management; these clauses enforce the following behaviors:

Include the `PROFILE` clause and a *profile_name* to associate a pre-defined profile with a role, or to change which pre-defined profile is associated with a user.

Include the `ACCOUNT` clause and the `LOCK` or `UNLOCK` keyword to specify that the user account should be placed in a locked or unlocked state.

Include the `LOCK TIME 'timestamp'` clause and a date/time value to lock the role at the specified time, and unlock the role at the time indicated by the `PASSWORD_LOCK_TIME` parameter of the profile assigned to this role. If `LOCK`

`TIME` is used with the `ACCOUNT LOCK` clause, the role can only be unlocked by a database superuser with the `ACCOUNT UNLOCK` clause.

Include the `PASSWORD EXPIRE` clause with the optional `AT 'timestamp'` keywords to specify a date/time when the password associated with the role will expire. If you omit the `AT 'timestamp'` keywords, the password will expire immediately.

Each login role may only have one profile. To discover the profile that is currently associated with a login role, query the `profile` column of the `DBA_USERS` view.

Parameters

`name`

The name of the role.

`profile_name`

The name of the profile associated with the role.

`timestamp`

The date and time at which the clause will be enforced. When specifying a value for `timestamp`, enclose the value in single-quotes.

Examples

The following example uses `CREATE USER` to create a login role named `john` who is associated with the `acctg_profile` profile:

```
CREATE USER john PROFILE acctg_profile IDENTIFIED BY "lsafepwd";
```

`john` can log in to the server, using the password `lsafepwd`.

The following example uses `CREATE ROLE` to create a login role named `john` who is associated with the `acctg_profile` profile:

```
CREATE ROLE john PROFILE acctg_profile LOGIN PASSWORD "lsafepwd";
```

`john` can log in to the server, using the password `lsafepwd`.

2.3.7 Backing up Profile Management Functions

A profile may include a `PASSWORD_VERIFY_FUNCTION` clause that refers to a user-defined function that specifies the behavior enforced by Advanced Server. Profiles are global objects; they are shared by all of the databases within a cluster. While profiles are global objects, user-defined functions are database objects.

Invoking `pg_dumpall` with the `-g` or `-r` option will create a script that recreates the definition of any existing profiles, but that does not recreate the user-defined functions that are referred to by the `PASSWORD_VERIFY_FUNCTION` clause. You should use the `pg_dump` utility to explicitly dump (and later restore) the database in which those functions reside.

The script created by `pg_dump` will contain a command that includes the clause and function name:

```
ALTER PROFILE... LIMIT PASSWORD_VERIFY_FUNCTION function_name
```

to associate the restored function with the profile with which it was previously associated.

If the `PASSWORD_VERIFY_FUNCTION` clause is set to `DEFAULT` or `NULL`, the behavior will be replicated by the script generated by the `pg_dumpall -g` or `pg_dumpall -r` command.

2.4 Optimizer Hints

When you invoke a `DELETE`, `INSERT`, `SELECT` or `UPDATE` command, the server generates a set of execution plans; after analyzing those execution plans, the server selects a plan that will (generally) return the result set in the least amount of time. The server's choice of plan is dependent upon several factors:

- The estimated execution cost of data handling operations.
- Parameter values assigned to parameters in the `Query Tuning` section of the `postgresql.conf` file.
- Column statistics that have been gathered by the `ANALYZE` command.

As a rule, the query planner will select the least expensive plan. You can use an *optimizer hint* to influence the server as it selects a query plan. An optimizer hint is a directive (or multiple directives) embedded in a comment-like syntax that immediately follows a `DELETE`, `INSERT`, `SELECT` or `UPDATE` command. Keywords in the comment instruct the server to employ or avoid a specific plan when producing the result set.

Synopsis

```
{ DELETE | INSERT | SELECT | UPDATE } /*+ { hint [ comment ] }
[...] */
statement_body

{ DELETE | INSERT | SELECT | UPDATE } --+ { hint [ comment ] }
[...]
statement_body
```

Optimizer hints may be included in either of the forms shown above. Note that in both forms, a plus sign (+) must immediately follow the `/*` or `--` opening comment symbols, with no intervening space, or the server will not interpret the following tokens as hints.

If you are using the first form, the hint and optional comment may span multiple lines. The second form requires all hints and comments to occupy a single line; the remainder of the statement must start on a new line.

Description

Please Note:

- The database server will always try to use the specified hints if at all possible.
- If a planner method parameter is set so as to disable a certain plan type, then this plan will not be used even if it is specified in a hint, unless there are no other possible options for the planner. Examples of planner method parameters are

`enable_indexscan`, `enable_seqscan`, `enable_hashjoin`,
`enable_mergejoin`, and `enable_nestloop`. These are all Boolean
parameters.

- Remember that the hint is embedded within a comment. As a consequence, if the hint is misspelled or if any parameter to a hint such as view, table, or column name is misspelled, or non-existent in the SQL command, there will be no indication that any sort of error has occurred. No syntax error will be given and the entire hint is simply ignored.
- If an alias is used for a table or view name in the SQL command, then the alias name, not the original object name, must be used in the hint. For example, in the command, `SELECT /*+ FULL(acct) */ * FROM accounts acct ...`, `acct`, the alias for `accounts`, must be specified in the `FULL` hint, not the table name, `accounts`.

Use the `EXPLAIN` command to ensure that the hint is correctly formed and the planner is using the hint. See the Advanced Server documentation set for information on the `EXPLAIN` command.

In general, optimizer hints should not be used in production applications (where table data changes throughout the life of the application). By ensuring that dynamic columns are `ANALYZED` frequently, the column statistics will be updated to reflect value changes, and the planner will use such information to produce the least cost plan for any given command execution. Use of optimizer hints defeats the purpose of this process and will result in the same plan regardless of how the table data changes.

Parameters

hint

An optimizer hint directive.

comment

A string with additional information. Note that there are restrictions as to what characters may be included in the comment. Generally, *comment* may only consist of alphabetic, numeric, the underscore, dollar sign, number sign and space characters. These must also conform to the syntax of an identifier. Any subsequent hint will be ignored if the comment is not in this form.

statement_body

The remainder of the `DELETE`, `INSERT`, `SELECT`, or `UPDATE` command.

The following sections describe the optimizer hint directives in more detail.

2.4.1 Default Optimization Modes

There are a number of optimization modes that can be chosen as the default setting for an Advanced Server database cluster. This setting can also be changed on a per session basis by using the `ALTER SESSION` command as well as in individual `DELETE`, `SELECT`, and `UPDATE` commands within an optimizer hint. The configuration parameter that controls these default modes is named `OPTIMIZER_MODE`. The following table shows the possible values.

Table 2-1 Default Optimization Modes

Hint	Description
<code>ALL_ROWS</code>	Optimizes for retrieval of all rows of the result set.
<code>CHOOSE</code>	Does no default optimization based on assumed number of rows to be retrieved from the result set. This is the default.
<code>FIRST_ROWS</code>	Optimizes for retrieval of only the first row of the result set.
<code>FIRST_ROWS_10</code>	Optimizes for retrieval of the first 10 rows of the results set.
<code>FIRST_ROWS_100</code>	Optimizes for retrieval of the first 100 rows of the result set.
<code>FIRST_ROWS_1000</code>	Optimizes for retrieval of the first 1000 rows of the result set.
<code>FIRST_ROWS(n)</code>	Optimizes for retrieval of the first <i>n</i> rows of the result set. This form may not be used as the object of the <code>ALTER SESSION SET OPTIMIZER_MODE</code> command. It may only be used in the form of a hint in a SQL command.

These optimization modes are based upon the assumption that the client submitting the SQL command is interested in viewing only the first “n” rows of the result set and will then abandon the remainder of the result set. Resources allocated to the query are adjusted as such.

Examples

Alter the current session to optimize for retrieval of the first 10 rows of the result set.

```
ALTER SESSION SET OPTIMIZER_MODE = FIRST_ROWS_10;
```

The current value of the `OPTIMIZER_MODE` parameter can be shown by using the `SHOW` command. Note that this command is a utility dependent command. In PSQL, the `SHOW` command is used as follows:

```
SHOW OPTIMIZER_MODE;
optimizer_mode
-----
first_rows_10
(1 row)
```

The `SHOW` command, compatible with Oracle databases, has the following syntax:

```
SHOW PARAMETER OPTIMIZER_MODE;
```

```
NAME
```

```
-----
```

```
VALUE
```

```
-----
```

```
optimizer_mode
```

```
first_rows_10
```

The following example shows an optimization mode used in a `SELECT` command as a hint:

```
SELECT /*+ FIRST_ROWS(7) */ * FROM emp;
```

empno	ename	job	mgr	hiredate	sal	comm	deptno
7369	SMITH	CLERK	7902	17-DEC-80 00:00:00	800.00		20
7499	ALLEN	SALESMAN	7698	20-FEB-81 00:00:00	1600.00	300.00	30
7521	WARD	SALESMAN	7698	22-FEB-81 00:00:00	1250.00	500.00	30
7566	JONES	MANAGER	7839	02-APR-81 00:00:00	1250.00		20
7654	MARTIN	SALESMAN	7698	28-SEP-81 00:00:00	1250.00	1400.00	30
7698	BLAKE	MANAGER	7839	01-MAY-81 00:00:00	2850.00		30
7782	CLARK	MANAGER	7839	09-JUN-81 00:00:00	2450.00		10
7788	SCOTT	ANALYST	7566	19-APR-87 00:00:00	3000.00		20
7839	KING	PRESIDENT		17-NOV-81 00:00:00	5000.00		10
7844	TURNER	SALESMAN	7698	08-SEP-81 00:00:00	1500.00	0.00	30
7876	ADAMS	CLERK	7788	23-MAY-87 00:00:00	1100.00		20
7900	JAMES	CLERK	7698	03-DEC-81 00:00:00	950.00		30
7902	FORD	ANALYST	7566	03-DEC-81 00:00:00	3000.00		20
7934	MILLER	CLERK	7782	23-JAN-82 00:00:00	1300.00		10

(14 rows)

2.4.2 Access Method Hints

The following hints influence how the optimizer accesses relations to create the result set.

Table 2-2 Access Method Hints

Hint	Description
FULL(<i>table</i>)	Perform a full sequential scan on <i>table</i> .
INDEX(<i>table</i> [<i>index</i>] [...])	Use <i>index</i> on <i>table</i> to access the relation.
NO_INDEX(<i>table</i> [<i>index</i>] [...])	Do not use <i>index</i> on <i>table</i> to access the relation.

In addition, the ALL_ROWS, FIRST_ROWS, and FIRST_ROWS(*n*) hints of Table 2-1 can be used.

Examples

The sample application does not have sufficient data to illustrate the effects of optimizer hints so the remainder of the examples in this section will use a banking database created by the pgbench application located in the Advanced Server bin subdirectory.

The following steps create a database named, bank, populated by the tables, pgbench_accounts, pgbench_branches, pgbench_tellers, and pgbench_history. The -s 20 option specifies a scaling factor of twenty, which results in the creation of twenty branches, each with 100,000 accounts, resulting in a total of 2,000,000 rows in the pgbench_accounts table and twenty rows in the pgbench_branches table. Ten tellers are assigned to each branch resulting in a total of 200 rows in the pgbench_tellers table.

The following initializes the pgbench application in the bank database.

```
createdb -U enterprisedb bank
CREATE DATABASE

pgbench -i -s 20 -U enterprisedb bank

NOTICE: table "pgbench_history" does not exist, skipping
NOTICE: table "pgbench_tellers" does not exist, skipping
NOTICE: table "pgbench_accounts" does not exist, skipping
NOTICE: table "pgbench_branches" does not exist, skipping
creating tables...
100000 of 2000000 tuples (5%) done (elapsed 0.11 s, remaining 2.10 s)
200000 of 2000000 tuples (10%) done (elapsed 0.22 s, remaining 1.98 s)
300000 of 2000000 tuples (15%) done (elapsed 0.33 s, remaining 1.84 s)
400000 of 2000000 tuples (20%) done (elapsed 0.42 s, remaining 1.67 s)
500000 of 2000000 tuples (25%) done (elapsed 0.52 s, remaining 1.57 s)
600000 of 2000000 tuples (30%) done (elapsed 0.62 s, remaining 1.45 s)
700000 of 2000000 tuples (35%) done (elapsed 0.73 s, remaining 1.35 s)
800000 of 2000000 tuples (40%) done (elapsed 0.87 s, remaining 1.31 s)
900000 of 2000000 tuples (45%) done (elapsed 0.98 s, remaining 1.19 s)
1000000 of 2000000 tuples (50%) done (elapsed 1.09 s, remaining 1.09 s)
```

```

1100000 of 2000000 tuples (55%) done (elapsed 1.22 s, remaining 1.00 s)
1200000 of 2000000 tuples (60%) done (elapsed 1.36 s, remaining 0.91 s)
1300000 of 2000000 tuples (65%) done (elapsed 1.51 s, remaining 0.82 s)
1400000 of 2000000 tuples (70%) done (elapsed 1.65 s, remaining 0.71 s)
1500000 of 2000000 tuples (75%) done (elapsed 1.78 s, remaining 0.59 s)
1600000 of 2000000 tuples (80%) done (elapsed 1.93 s, remaining 0.48 s)
1700000 of 2000000 tuples (85%) done (elapsed 2.10 s, remaining 0.37 s)
1800000 of 2000000 tuples (90%) done (elapsed 2.23 s, remaining 0.25 s)
1900000 of 2000000 tuples (95%) done (elapsed 2.37 s, remaining 0.12 s)
2000000 of 2000000 tuples (100%) done (elapsed 2.48 s, remaining 0.00 s)
vacuum...
set primary keys...
done.

```

A total of 500,00 transactions are then processed. This will populate the pgbench_history table with 500,000 rows.

```

pgbench -U enterpriseDB -t 500000 bank

starting vacuum...end.
transaction type: <builtin: TPC-B (sort of)>
scaling factor: 20
query mode: simple
number of clients: 1
number of threads: 1
number of transactions per client: 500000
number of transactions actually processed: 500000/500000
latency average: 0.000 ms
tps = 1464.338375 (including connections establishing)
tps = 1464.350357 (excluding connections establishing)

```

The table definitions are shown below:

```

\dt pgbench_accounts

Table "public.pgbench_accounts"
 Column | Type | Modifiers
-----+-----+-----
 aid   | integer | not null
 bid   | integer |
 abalance | integer |
 filler | character(84) |

Indexes:
 "pgbench_accounts_pkey" PRIMARY KEY, btree (aid)

\dt pgbench_branches

Table "public.pgbench_branches"
 Column | Type | Modifiers
-----+-----+-----
 bid   | integer | not null
 bbalance | integer |
 filler | character(88) |

Indexes:
 "pgbench_branches_pkey" PRIMARY KEY, btree (bid)

\dt pgbench_tellers

Table "public.pgbench_tellers"
 Column | Type | Modifiers
-----+-----+-----

```

```

-----+-----+-----+
tid   | integer      | not null
bid   | integer      |
tbalance | integer      |
filler | character(84) |
Indexes:
  "pgbench_tellers_pkey" PRIMARY KEY, btree (tid)

\d pgbench_history

      Table "public.pgbench_history"
 Column |          Type          | Modifiers
-----+-----+-----+
tid   | integer      |
bid   | integer      |
aid   | integer      |
delta | integer      |
mtime | timestamp without time zone |
filler | character(22) |

```

The EXPLAIN command shows the plan selected by the query planner. In the following example, aid is the primary key column, so an indexed search is used on index, pgbench_accounts_pkey.

```

EXPLAIN SELECT * FROM pgbench_accounts WHERE aid = 100;

          QUERY PLAN
-----
Index Scan using pgbench_accounts_pkey on pgbench_accounts  (cost=0.43..8.45
rows=1 width=97)
  Index Cond: (aid = 100)
(2 rows)

```

The FULL hint is used to force a full sequential scan instead of using the indexes shown below:

```

EXPLAIN SELECT /*+ FULL(pgbench_accounts) */ * FROM pgbench_accounts WHERE
aid = 100;

          QUERY PLAN
-----
Seq Scan on pgbench_accounts  (cost=0.00..58781.69 rows=1 width=97)
  Filter: (aid = 100)
(2 rows)

```

The NO_INDEX hint forces a parallel sequential scan instead of use of the indexes shown below:

```

EXPLAIN SELECT /*+ NO_INDEX(pgbench_accounts pgbench_accounts_pkey) */ * FROM
pgbench_accounts WHERE aid = 100;

          QUERY PLAN
-----
Gather  (cost=1000.00..45094.80 rows=1 width=97)
  Workers Planned: 2

```

```
-> Parallel Seq Scan on pgbench_accounts  (cost=0.00..44094.70 rows=1
width=97)
      Filter: (aid = 100)
(4 rows)
```

In addition to using the `EXPLAIN` command as shown in the prior examples, more detailed information regarding whether or not a hint was used by the planner can be obtained by setting the `trace hints` configuration parameter as follows:

```
SET trace hints TO on;
```

The `SELECT` command with the `NO_INDEX` hint is repeated below to illustrate the additional information produced when the `trace hints` configuration parameters is set.

```
EXPLAIN SELECT /*+ NO_INDEX(pgbench_accounts pgbench_accounts_pkey) */ * FROM pgbench_accounts WHERE aid = 100;

INFO: [HINTS] Index Scan of [pgbench_accounts].[pgbench_accounts_pkey]
rejected due to NO_INDEX hint.

QUERY PLAN
-----
-----
Gather  (cost=1000.00..45094.80 rows=1 width=97)
  Workers Planned: 2
    -> Parallel Seq Scan on pgbench_accounts  (cost=0.00..44094.70 rows=1
width=97)
          Filter: (aid = 100)
(4 rows)
```

Note that if a hint is ignored, the `INFO: [HINTS]` line will not appear. This may be an indication that there was a syntax error or some other misspelling in the hint as shown in the following example where the indexname is misspelled.

```
EXPLAIN SELECT /*+ NO_INDEX(pgbench_accounts pgbench_accounts_xxx) */ * FROM pgbench_accounts WHERE aid = 100;

                                     QUERY PLAN
-----
-----
      Index Scan using pgbench_accounts_pkey on pgbench_accounts  (cost=0.43..8.45
rows=1 width=97)
          Index Cond: (aid = 100)
(2 rows)
```

2.4.3 Specifying a Join Order

Include the `ORDERED` directive to instruct the query optimizer to join tables in the order in which they are listed in the `FROM` clause. If you do not include the `ORDERED` keyword, the query optimizer will choose the order in which to join the tables.

For example, the following command allows the optimizer to choose the order in which to join the tables listed in the `FROM` clause:

```
SELECT e.ename, d.dname, h.startdate
  FROM emp e, dept d, jobhist h
 WHERE d.deptno = e.deptno
   AND h.empno = e.empno;
```

The following command instructs the optimizer to join the tables in the ordered specified:

```
SELECT /*+ ORDERED */ e.ename, d.dname, h.startdate
  FROM emp e, dept d, jobhist h
 WHERE d.deptno = e.deptno
   AND h.empno = e.empno;
```

In the `ORDERED` version of the command, Advanced Server will first join `emp e` with `dept d` before joining the results with `jobhist h`. Without the `ORDERED` directive, the join order is selected by the query optimizer.

Please note: the `ORDERED` directive does not work for Oracle-style outer joins (those joins that contain a '+' sign).

2.4.4 Joining Relations Hints

When two tables are to be joined, there are three possible plans that may be used to perform the join.

- *Nested Loop Join* – A table is scanned once for every row in the other joined table.
- *Merge Sort Join* – Each table is sorted on the join attributes before the join starts. The two tables are then scanned in parallel and the matching rows are combined to form the join rows.
- *Hash Join* – A table is scanned and its join attributes are loaded into a hash table using its join attributes as hash keys. The other joined table is then scanned and its join attributes are used as hash keys to locate the matching rows from the first table.

The following table lists the optimizer hints that can be used to influence the planner to use one type of join plan over another.

Table 2-3 Join Hints

Hint	Description
USE_HASH(<i>table</i> [...])	Use a hash join for <i>table</i> .
NO_USE_HASH(<i>table</i> [...])	Do not use a hash join for <i>table</i> .
USE_MERGE(<i>table</i> [...])	Use a merge sort join for <i>table</i> .
NO_USE_MERGE(<i>table</i> [...])	Do not use a merge sort join for <i>table</i> .
USE_NL(<i>table</i> [...])	Use a nested loop join for <i>table</i> .
NO_USE_NL(<i>table</i> [...])	Do not use a nested loop join for <i>table</i> .

Examples

In the following example, the `USE_HASH` hint is used for a join on the `pgbench_branches` and `pgbench_accounts` tables. The query plan shows that a hash join is used by creating a hash table from the join attribute of the `pgbench_branches` table.

```
EXPLAIN SELECT /*+ USE_HASH(b) */ b.bid, a.aid, abalance FROM
pgbench_branches b, pgbench_accounts a WHERE b.bid = a.bid;

          QUERY PLAN
-----
Hash Join  (cost=21.45..81463.06 rows=2014215 width=12)
  Hash Cond: (a.bid = b.bid)
    -> Seq Scan on pgbench_accounts a  (cost=0.00..53746.15 rows=2014215
width=12)
        -> Hash  (cost=21.20..21.20 rows=20 width=4)
            -> Seq Scan on pgbench_branches b  (cost=0.00..21.20 rows=20
width=4)
```

(5 rows)

Next, the `NO_USE_HASH(a b)` hint forces the planner to use an approach other than hash tables. The result is a merge join.

```
EXPLAIN SELECT /*+ NO_USE_HASH(a b) */ b.bid, a.aid, abalance FROM
pgbench_branches b, pgbench_accounts a WHERE b.bid = a.bid;

QUERY PLAN
-----
-----  

Merge Join  (cost=333526.08..368774.94 rows=2014215 width=12)
  Merge Cond: (b.bid = a.bid)
    -> Sort  (cost=21.63..21.68 rows=20 width=4)
      Sort Key: b.bid
      -> Seq Scan on pgbench_branches b  (cost=0.00..21.20 rows=20
width=4)
    -> Materialize  (cost=333504.45..343575.53 rows=2014215 width=12)
      -> Sort  (cost=333504.45..338539.99 rows=2014215 width=12)
        Sort Key: a.bid
        -> Seq Scan on pgbench_accounts a  (cost=0.00..53746.15
rows=2014215 width=12)
(9 rows)
```

Finally, the `USE_MERGE` hint forces the planner to use a merge join.

```
EXPLAIN SELECT /*+ USE_MERGE(a) */ b.bid, a.aid, abalance FROM
pgbench_branches b, pgbench_accounts a WHERE b.bid = a.bid;

QUERY PLAN
-----
-----  

Merge Join  (cost=333526.08..368774.94 rows=2014215 width=12)
  Merge Cond: (b.bid = a.bid)
    -> Sort  (cost=21.63..21.68 rows=20 width=4)
      Sort Key: b.bid
      -> Seq Scan on pgbench_branches b  (cost=0.00..21.20 rows=20
width=4)
    -> Materialize  (cost=333504.45..343575.53 rows=2014215 width=12)
      -> Sort  (cost=333504.45..338539.99 rows=2014215 width=12)
        Sort Key: a.bid
        -> Seq Scan on pgbench_accounts a  (cost=0.00..53746.15
rows=2014215 width=12)
(9 rows)
```

In this three-table join example, the planner first performs a hash join on the `pgbench_branches` and `pgbench_history` tables, then finally performs a hash join of the result with the `pgbench_accounts` table.

```
EXPLAIN SELECT h.mtime, h.delta, b.bid, a.aid FROM pgbench_history h, pgbench_branches
b, pgbench_accounts a WHERE h.bid = b.bid AND h.aid = a.aid;

QUERY PLAN
-----
--  

Hash Join  (cost=86814.29..123103.29 rows=500000 width=20)
  Hash Cond: (h.aid = a.aid)
    -> Hash Join  (cost=21.45..15081.45 rows=500000 width=20)
      Hash Cond: (h.bid = b.bid)
      -> Seq Scan on pgbench_history h  (cost=0.00..8185.00 rows=500000 width=20)
```

```
-> Hash (cost=21.20..21.20 rows=20 width=4)
      -> Seq Scan on pgbench_branches b (cost=0.00..21.20 rows=20 width=4)
-> Hash (cost=53746.15..53746.15 rows=2014215 width=4)
      -> Seq Scan on pgbench_accounts a (cost=0.00..53746.15 rows=2014215 width=4)
(9 rows)
```

This plan is altered by using hints to force a combination of a merge sort join and a hash join.

```
EXPLAIN SELECT /*+ USE_MERGE(h b) USE_HASH(a) */ hmtime, h.delta, b.bid, a.aid FROM
pgbench_history h, pgbench_branches b, pgbench_accounts a WHERE h.bid = b.bid AND h.aid
= a.aid;

                                     QUERY PLAN
-----
Hash Join  (cost=152583.39..182562.49 rows=500000 width=20)
  Hash Cond: (h.aid = a.aid)
  -> Merge Join  (cost=65790.55..74540.65 rows=500000 width=20)
      Merge Cond: (b.bid = h.bid)
      -> Sort  (cost=21.63..21.68 rows=20 width=4)
          Sort Key: b.bid
          -> Seq Scan on pgbench_branches b  (cost=0.00..21.20 rows=20 width=4)
      -> Materialize  (cost=65768.92..68268.92 rows=500000 width=20)
          -> Sort  (cost=65768.92..67018.92 rows=500000 width=20)
              Sort Key: h.bid
              -> Seq Scan on pgbench_history h  (cost=0.00..8185.00 rows=500000
width=20)
      -> Hash  (cost=53746.15..53746.15 rows=2014215 width=4)
          -> Seq Scan on pgbench_accounts a  (cost=0.00..53746.15 rows=2014215 width=4)
(13 rows)
```

2.4.5 Global Hints

Thus far, hints have been applied directly to tables that are referenced in the SQL command. It is also possible to apply hints to tables that appear in a view when the view is referenced in the SQL command. The hint does not appear in the view, itself, but rather in the SQL command that references the view.

When specifying a hint that is to apply to a table within a view, the view and table names are given in dot notation within the hint argument list.

Synopsis

hint(*view.table*)

Parameters

hint

Any of the hints in Table 2-2 or Table 2-3.

view

The name of the view containing *table*.

table

The table on which the hint is to be applied.

Examples

A view named, `tx`, is created from the three-table join of `pgbench_history`, `pgbench_branches`, and `pgbench_accounts` shown in the final example of Section 2.4.4.

```
CREATE VIEW tx AS SELECT h.mtime, h.delta, b.bid, a.aid FROM pgbench_history
h, pgbench_branches b, pgbench_accounts a WHERE h.bid = b.bid AND h.aid =
a.aid;
```

The query plan produced by selecting from this view is shown below:

```
EXPLAIN SELECT * FROM tx;
                                         QUERY PLAN
-----
-
 Hash Join  (cost=86814.29..123103.29 rows=500000 width=20)
   Hash Cond: (h.aid = a.aid)
     -> Hash Join  (cost=21.45..15081.45 rows=500000 width=20)
```

```

Hash Cond: (h.bid = b.bid)
-> Seq Scan on pgbench_history h  (cost=0.00..8185.00 rows=500000 width=20)
-> Hash  (cost=21.20..21.20 rows=20 width=4)
    -> Seq Scan on pgbench_branches b  (cost=0.00..21.20 rows=20 width=4)
-> Hash  (cost=53746.15..53746.15 rows=2014215 width=4)
    -> Seq Scan on pgbench_accounts a  (cost=0.00..53746.15 rows=2014215 width=4)
(9 rows)

```

The same hints that were applied to this join at the end of Section [2.4.4](#) can be applied to the view as follows:

```

EXPLAIN SELECT /*+ USE_MERGE(tx.h tx.b) USE_HASH(tx.a) */ * FROM tx;
                                                     QUERY PLAN
-----
-----
Hash Join  (cost=152583.39..182562.49 rows=500000 width=20)
  Hash Cond: (h.aid = a.aid)
  -> Merge Join  (cost=65790.55..74540.65 rows=500000 width=20)
      Merge Cond: (b.bid = h.bid)
      -> Sort  (cost=21.63..21.68 rows=20 width=4)
          Sort Key: b.bid
          -> Seq Scan on pgbench_branches b  (cost=0.00..21.20 rows=20 width=4)
      -> Materialize  (cost=65768.92..68268.92 rows=500000 width=20)
          -> Sort  (cost=65768.92..67018.92 rows=500000 width=20)
              Sort Key: h.bid
              -> Seq Scan on pgbench_history h  (cost=0.00..8185.00 rows=500000
width=20)
      -> Hash  (cost=53746.15..53746.15 rows=2014215 width=4)
          -> Seq Scan on pgbench_accounts a  (cost=0.00..53746.15 rows=2014215 width=4)
(13 rows)

```

In addition to applying hints to tables within stored views, hints can be applied to tables within subqueries as illustrated by the following example. In this query on the sample application `emp` table, employees and their managers are listed by joining the `emp` table with a subquery of the `emp` table identified by the alias, `b`.

```

SELECT a.empno, a.ename, b.empno "mgr empno", b.ename "mgr ename" FROM emp a,
(SELECT * FROM emp) b WHERE a.mgr = b.empno;

empno | ename | mgr empno | mgr ename
-----+-----+-----+-----+
7369 | SMITH | 7902 | FORD
7499 | ALLEN | 7698 | BLAKE
7521 | WARD | 7698 | BLAKE
7566 | JONES | 7839 | KING
7654 | MARTIN | 7698 | BLAKE
7698 | BLAKE | 7839 | KING
7782 | CLARK | 7839 | KING
7788 | SCOTT | 7566 | JONES
7844 | TURNER | 7698 | BLAKE
7876 | ADAMS | 7788 | SCOTT
7900 | JAMES | 7698 | BLAKE
7902 | FORD | 7566 | JONES
7934 | MILLER | 7782 | CLARK
(13 rows)

```

The plan chosen by the query planner is shown below:

```

EXPLAIN SELECT a.empno, a.ename, b.empno "mgr empno", b.ename "mgr ename"
FROM emp a, (SELECT * FROM emp) b WHERE a.mgr = b.empno;

```

```

-----  

          QUERY PLAN  

-----  

Hash Join  (cost=1.32..2.64 rows=13 width=22)  

  Hash Cond: (a.mgr = emp.empno)  

    -> Seq Scan on emp a  (cost=0.00..1.14 rows=14 width=16)  

    -> Hash  (cost=1.14..1.14 rows=14 width=11)  

        -> Seq Scan on emp  (cost=0.00..1.14 rows=14 width=11)  

(5 rows)

```

A hint can be applied to the `emp` table within the subquery to perform an index scan on index, `emp_pk`, instead of a table scan. Note the difference in the query plans.

```

EXPLAIN SELECT /*+ INDEX(b.emp emp_pk) */ a.empno, a.ename, b.empno "mgr  

empno", b.ename "mgr ename" FROM emp a, (SELECT * FROM emp) b WHERE a.mgr =  

b.empno;

```

```

-----  

          QUERY PLAN  

-----  

Merge Join  (cost=4.17..13.11 rows=13 width=22)  

  Merge Cond: (a.mgr = emp.empno)  

    -> Sort  (cost=1.41..1.44 rows=14 width=16)  

        Sort Key: a.mgr  

        -> Seq Scan on emp a  (cost=0.00..1.14 rows=14 width=16)  

    -> Index Scan using emp_pk on emp  (cost=0.14..12.35 rows=14 width=11)  

(6 rows)

```

2.4.6 Using the APPEND Optimizer Hint

By default, Advanced Server will add new data into the first available free-space in a table (vacated by vacuumed records). Include the `APPEND` directive after an `INSERT` or `SELECT` command to instruct the server to bypass mid-table free space, and affix new rows to the end of the table. This optimizer hint can be particularly useful when bulk loading data.

The syntax is:

```
/*+APPEND*/
```

For example, the following command, compatible with Oracle databases, instructs the server to append the data in the `INSERT` statement to the end of the `sales` table:

```
INSERT /*+APPEND*/ INTO sales VALUES  
(10, 10, '01-Mar-2011', 10, 'OR');
```

Note that Advanced Server supports the `APPEND` hint when adding multiple rows in a single `INSERT` statement:

```
INSERT /*+APPEND*/ INTO sales VALUES  
(20, 20, '01-Aug-2011', 20, 'NY'),  
(30, 30, '01-Feb-2011', 30, 'FL'),  
(40, 40, '01-Nov-2011', 40, 'TX');
```

The `APPEND` hint can also be included in the `SELECT` clause of an `INSERT INTO` statement:

```
INSERT INTO sales_history SELECT /*+APPEND*/ FROM sales;
```

2.4.7 Parallelism Hints

The `PARALLEL` optimizer hint is used to force parallel scanning.

The `NO_PARALLEL` optimizer hint prevents usage of a parallel scan.

Synopsis

```
PARALLEL (table [ parallel_degree | DEFAULT ])
```

```
NO_PARALLEL (table)
```

Description

Parallel scanning is the usage of multiple background workers to simultaneously perform a scan of a table (that is, in parallel) for a given query. This process provides performance improvement over other methods such as the sequential scan.

Parameters

table

The table to which the parallel hint is to be applied.

parallel_degree | `DEFAULT`

parallel_degree is a positive integer that specifies the desired number of workers to use for a parallel scan. If specified, the lesser of *parallel_degree* and configuration parameter `max_parallel_workers_per_gather` is used as the planned number of workers. For information on the `max_parallel_workers_per_gather` parameter, please see Section 19.4.6 Asynchronous Behavior located in Section 19.4 Resource Consumption in the PostgreSQL core documentation available at:

<https://www.postgresql.org/docs/10/static/runtime-config-resource.html>

If `DEFAULT` is specified, then the maximum possible parallel degree is used.

If both *parallel_degree* and `DEFAULT` are omitted, then the query optimizer determines the parallel degree. In this case, if *table* has been set with the `parallel_workers` storage parameter, then this value is used as the parallel degree, otherwise the optimizer uses the maximum possible parallel degree as if `DEFAULT` was specified. For information on the `parallel_workers` storage

parameter, please see the `Storage Parameters` subsection located under `CREATE TABLE` in the PostgreSQL core documentation available at:

<https://www.postgresql.org/docs/10/static/sql-createtable.html>

Regardless of the circumstance, the parallel degree never exceeds the setting of configuration parameter `max_parallel_workers_per_gather`.

Examples

The following configuration parameter settings are in effect:

```
SHOW max_worker_processes;
max_worker_processes
-----
8
(1 row)

SHOW max_parallel_workers_per_gather;
max_parallel_workers_per_gather
-----
2
(1 row)
```

The following example shows the default scan on table `pgbench_accounts`. Note that a sequential scan is shown in the query plan.

```
SET trace_hints TO on;

EXPLAIN SELECT * FROM pgbench_accounts;
               QUERY PLAN
-----
 Seq Scan on pgbench_accounts  (cost=0.00..53746.15 rows=2014215 width=97)
(1 row)
```

The following example uses the `PARALLEL` hint. In the query plan, the `Gather` node, which launches the background workers, indicates that two workers are planned to be used.

Note: If `trace_hints` is set to `on`, the `INFO: [HINTS]` lines appear stating that `PARALLEL` has been accepted for `pgbench_accounts` as well as other hint information. For the remaining examples, these lines will not be displayed as they generally show the same output (that is, `trace_hints` has been reset to `off`).

```
EXPLAIN SELECT /*+ PARALLEL(pgbench_accounts) */ * FROM pgbench_accounts;

INFO: [HINTS] SeqScan of [pgbench_accounts] rejected due to PARALLEL hint.
INFO: [HINTS] PARALLEL on [pgbench_accounts] accepted.
INFO: [HINTS] Index Scan of [pgbench_accounts].[pgbench_accounts_pkey]
rejected due to PARALLEL hint.
```

```

-----  

-----  

      Gather  (cost=1000.00..244418.06 rows=2014215 width=97)  

      Workers Planned: 2  

      -> Parallel Seq Scan on pgbench_accounts  (cost=0.00..41996.56  

rows=839256 width=97)  

(3 rows)
-----
```

Now, the `max_parallel_workers_per_gather` setting is increased:

```

SET max_parallel_workers_per_gather TO 6;  

SHOW max_parallel_workers_per_gather;  

max_parallel_workers_per_gather  

-----  

6  

(1 row)
```

The same query on `pgbench_accounts` is issued again with no parallel degree specification in the `PARALLEL` hint. Note that the number of planned workers has increased to 4 as determined by the optimizer.

```

EXPLAIN SELECT /*+ PARALLEL(pgbench_accounts) */ * FROM pgbench_accounts;

-----  

-----  

      Gather  (cost=1000.00..241061.04 rows=2014215 width=97)  

      Workers Planned: 4  

      -> Parallel Seq Scan on pgbench_accounts  (cost=0.00..38639.54  

rows=503554 width=97)  

(3 rows)
-----
```

Now, a value of 6 is specified for the parallel degree parameter of the `PARALLEL` hint. The planned number of workers is now returned as this specified value:

```

EXPLAIN SELECT /*+ PARALLEL(pgbench_accounts 6) */ * FROM pgbench_accounts;

-----  

-----  

      Gather  (cost=1000.00..239382.52 rows=2014215 width=97)  

      Workers Planned: 6  

      -> Parallel Seq Scan on pgbench_accounts  (cost=0.00..36961.03  

rows=335702 width=97)  

(3 rows)
-----
```

The same query is now issued with the `DEFAULT` setting for the parallel degree. The results indicate that the maximum allowable number of workers is planned.

```

EXPLAIN SELECT /*+ PARALLEL(pgbench_accounts DEFAULT) */ * FROM
pgbench_accounts;
```

```

-----
Gather  (cost=1000.00..239382.52 rows=2014215 width=97)
  Workers Planned: 6
    -> Parallel Seq Scan on pgbench_accounts  (cost=0.00..36961.03
rows=335702 width=97)
(3 rows)

```

Table pgbench_accounts is now altered so that the parallel_workers storage parameter is set to 3.

Note: This format of the ALTER TABLE command to set the parallel_workers parameter is not compatible with Oracle databases.

The parallel_workers setting is shown by the PSQL \d+ command.

```

ALTER TABLE pgbench_accounts SET (parallel_workers=3);

\dt+ pgbench_accounts
      Table "public.pgbench_accounts"
 Column | Type            | Modifiers | Storage | Stats target | Description
-----+-----+-----+-----+-----+
 aid    | integer         | not null | plain   |             |
 bid    | integer         |           | plain   |             |
 abalance | integer        |           | plain   |             |
 filler  | character(84)  |           | extended|             |
Indexes:
  "pgbench_accounts_pkey" PRIMARY KEY, btree (aid)
Options: fillfactor=100, parallel_workers=3

```

Now, when the PARALLEL hint is given with no parallel degree, the resulting number of planned workers is the value from the parallel_workers parameter:

```

EXPLAIN SELECT /*+ PARALLEL(pgbench_accounts) */ * FROM pgbench_accounts;
               QUERY PLAN
-----
Gather  (cost=1000.00..242522.97 rows=2014215 width=97)
  Workers Planned: 3
    -> Parallel Seq Scan on pgbench_accounts  (cost=0.00..40101.47
rows=649747 width=97)
(3 rows)

```

Specifying a parallel degree value or DEFAULT in the PARALLEL hint overrides the parallel_workers setting.

The following example shows the NO_PARALLEL hint. Note that with trace_hints set to on, the INFO: [HINTS] message states that the parallel scan was rejected due to the NO_PARALLEL hint.

```

EXPLAIN SELECT /*+ NO_PARALLEL(pgbench_accounts) */ * FROM pgbench_accounts;
INFO: [HINTS] Parallel SeqScan of [pgbench_accounts] rejected due to
NO_PARALLEL hint.

```

QUERY PLAN

```
-----  
Seq Scan on pgbench_accounts  (cost=0.00..53746.15 rows=2014215 width=97)  
(1 row)
```

2.4.8 Conflicting Hints

If a command includes two or more conflicting hints, the server will ignore the contradictory hints. The following table lists hints that are contradictory to each other.

Table 2-4 Conflicting Hints

Hint	Conflicting Hint
ALL_ROWS	FIRST_ROWS - all formats
FULL(<i>table</i>)	INDEX(<i>table</i> [<i>index</i>]) PARALLEL(<i>table</i> [<i>degree</i>])
INDEX(<i>table</i>)	FULL(<i>table</i>) NO_INDEX(<i>table</i>) PARALLEL(<i>table</i> [<i>degree</i>])
INDEX(<i>table index</i>)	FULL(<i>table</i>) NO_INDEX(<i>table index</i>) PARALLEL(<i>table</i> [<i>degree</i>])
PARALLEL(<i>table</i> [<i>degree</i>])	FULL(<i>table</i>) INDEX(<i>table</i>) NO_PARALLEL(<i>table</i>)
USE_HASH(<i>table</i>)	NO_USE_HASH(<i>table</i>)
USE_MERGE(<i>table</i>)	NO_USE_MERGE(<i>table</i>)
USE_NL(<i>table</i>)	NO_USE_NL(<i>table</i>)

3 Stored Procedure Language

This chapter describes the Stored Procedure Language (SPL). SPL is a highly productive, procedural programming language for writing custom procedures, functions, triggers, and packages for Advanced Server that provides:

- full procedural programming functionality to complement the SQL language
- a single, common language to create stored procedures, functions, triggers, and packages for the Advanced Server database
- a seamless development and testing environment
- the use of reusable code
- ease of use

This chapter describes the basic elements of an SPL program, before providing an overview of the organization of an SPL program and how it is used to create a procedure or a function. Triggers, while still utilizing SPL, are sufficiently different to warrant a separate discussion (see Section 4 for information about triggers). Packages are discussed in the *Database Compatibility for Oracle Developers Built-in Package Guide* available at:

<http://www.enterprisedb.com/products-services-training/products/documentation>

The remaining sections of this chapter delve into the details of the SPL language and provide examples of its application.

3.1 Basic SPL Elements

This section discusses the basic programming elements of an SPL program.

3.1.1 Character Set

SPL programs are written using the following set of characters:

- Uppercase letters A thru Z and lowercase letters a thru z
- Digits 0 thru 9
- Symbols () + - * / < > = ! ~ ^ ; : . ' @ % , " # \$ & _ | { } ? []
- White space characters tabs, spaces, and carriage returns

Identifiers, expressions, statements, control structures, etc. that comprise the SPL language are written using these characters.

Note: The data that can be manipulated by an SPL program is determined by the character set supported by the database encoding.

3.1.2 Case Sensitivity

Keywords and user-defined identifiers that are used in an SPL program are case insensitive. So for example, the statement `DBMS_OUTPUT.PUT_LINE('Hello World');` is interpreted to mean the same thing as `dbms_output.put_line('Hello World');` or `Dbms_Output.Put_Line('Hello World');` or `DBMS_output.Put_line('Hello World');`.

Character and string constants, however, are case sensitive as well as any data retrieved from the Advanced Server database or data obtained from other external sources. The statement `DBMS_OUTPUT.PUT_LINE('Hello World!');` produces the following output:

```
Hello World!
```

However the statement `DBMS_OUTPUT.PUT_LINE('HELLO WORLD!');` produces the output:

```
HELLO WORLD!
```

3.1.3 Identifiers

Identifiers are user-defined names that are used to identify various elements of an SPL program including variables, cursors, labels, programs, and parameters. The syntax rules for valid identifiers are the same as for identifiers in the SQL language.

An identifier must not be the same as an SPL keyword or a keyword of the SQL language. The following are some examples of valid identifiers:

```
x
last__name
a__$Sign
Many$$$$$$$$signs_____
THIS_IS_AN_EXTREMELY_LONG_NAME
A1
```

3.1.4 Qualifiers

A *qualifier* is a name that specifies the owner or context of an entity that is the object of the qualification. A qualified object is specified as the qualifier name followed by a dot with no intervening white space, followed by the name of the object being qualified with no intervening white space. This syntax is called *dot notation*.

The following is the syntax of a qualified object.

qualifier. [*qualifier.*]... *object*

qualifier is the name of the owner of the object. *object* is the name of the entity belonging to *qualifier*. It is possible to have a chain of qualifications where the preceding qualifier owns the entity identified by the subsequent qualifier(s) and object.

Almost any identifier can be qualified. What an identifier is qualified by depends upon what the identifier represents and the context of its usage.

Some examples of qualification follow:

- Procedure and function names qualified by the schema to which they belong - e.g., *schema_name.procedure_name*(...)
- Trigger names qualified by the schema to which they belong - e.g., *schema_name.trigger_name*
- Column names qualified by the table to which they belong - e.g., *emp.empno*
- Table names qualified by the schema to which they belong - e.g., *public.emp*
- Column names qualified by table and schema - e.g., *public.emp.empno*

As a general rule, wherever a name appears in the syntax of an SPL statement, its qualified name can be used as well. Typically a qualified name would only be used if there is some ambiguity associated with the name. For example, if two procedures with the same name belonging to two different schemas are invoked from within a program or if the same name is used for a table column and SPL variable within the same program.

You should avoid using qualified names if at all possible. In this chapter, the following conventions are adopted to avoid naming conflicts:

- All variables declared in the declaration section of an SPL program are prefixed by *v_*. E.g., *v_empno*
- All formal parameters declared in a procedure or function definition are prefixed by *p_*. E.g., *p_empno*
- Column names and table names do not have any special prefix conventions. E.g., column *empno* in table *emp*

3.1.5 Constants

Constants or *literals* are fixed values that can be used in SPL programs to represent values of various types - e.g., numbers, strings, dates, etc. Constants come in the following types:

- Numeric (Integer and Real)
- Character and String
- Date/time

3.1.6 User-Defined PL/SQL Subtypes

Advanced Server supports user-defined PL/SQL subtypes and (subtype) aliases. A subtype is a data type with an optional set of constraints that restrict the values that can be stored in a column of that type. The rules that apply to the type on which the subtype is based are still enforced, but you can use additional constraints to place limits on the precision or scale of values stored in the type.

You can define a subtype in the declaration of a PL function, procedure, anonymous block or package. The syntax is:

```
SUBTYPE subtype_name IS type_name [ (constraint) ] [NOT NULL]
```

Where *constraint* is:

```
{precision [, scale] } | length
```

Where:

subtype_name

subtype_name specifies the name of the subtype.

type_name

type_name specifies the name of the original type on which the subtype is based. *type_name* may be:

- The name of any of the type supported by Advanced Server.
- The name of any composite type.
- A column anchored by a %TYPE operator.
- The name of another subtype.

Include the *constraint* clause to define restrictions for types that support precision or scale.

precision

precision specifies the total number of digits permitted in a value of the subtype.

scale

scale specifies the number of fractional digits permitted in a value of the subtype.

length

length specifies the total length permitted in a value of CHARACTER, VARCHAR, or TEXT base types

Include the NOT NULL clause to specify that NULL values may not be stored in a column of the specified subtype.

Note that a subtype that is based on a column will inherit the column size constraints, but the subtype will not inherit NOT NULL or CHECK constraints.

Unconstrained Subtypes

To create an unconstrained subtype, use the SUBTYPE command to specify the new subtype name and the name of the type on which the subtype is based. For example, the following command creates a subtype named `address` that has all of the attributes of the type, CHAR:

```
SUBTYPE address IS CHAR;
```

You can also create a subtype (constrained or unconstrained) that is a subtype of another subtype:

```
SUBTYPE cust_address IS address NOT NULL;
```

This command creates a subtype named `cust_address` that shares all of the attributes of the `address` subtype. Include the NOT NULL clause to specify that a value of the `cust_address` may not be NULL.

Constrained Subtypes

Include a *length* value when creating a subtype that is based on a character type to define the maximum length of the subtype. For example:

```
SUBTYPE acct_name IS VARCHAR (15);
```

This example creates a subtype named `acct_name` that is based on a VARCHAR data type, but is limited to 15 characters in length.

Include values for *precision* (to specify the maximum number of digits in a value of the subtype) and optionally, *scale* (to specify the number of digits to the right of the decimal point) when constraining a numeric base type. For example:

```
SUBTYPE acct_balance IS NUMBER (5, 2);
```

This example creates a subtype named `acct_balance` that shares all of the attributes of a `NUMBER` type, but that may not exceed 3 digits to the left of the decimal point and 2 digits to the right of the decimal.

An argument declaration (in a function or procedure header) is a *formal argument*. The value passed to a function or procedure is an *actual argument*. When invoking a function or procedure, the caller provides (0 or more) actual arguments. Each actual argument is assigned to a formal argument that holds the value within the body of the function or procedure.

If a formal argument is declared as a constrained subtype:

- Advanced Server does not enforce subtype constraints when assigning an actual argument to a formal argument when invoking a function.
- Advanced Server enforces subtype constraints when assigning an actual argument to a formal argument when invoking a procedure.

Using the % TYPE Operator

You can use `%TYPE` notation to declare a subtype anchored to a column. For example:

```
SUBTYPE emp_type IS emp.empno%TYPE
```

This command creates a subtype named `emp_type` whose base type matches the type of the `empno` column in the `emp` table. A subtype that is based on a column will share the column size constraints; `NOT NULL` and `CHECK` constraints are not inherited.

Subtype Conversion

Unconstrained subtypes are aliases for the type on which they are based. Any variable of type subtype (unconstrained) is interchangeable with a variable of the base type without conversion, and vice versa.

A variable of a constrained subtype may be interchanged with a variable of the base type without conversion, but a variable of the base type may only be interchanged with a constrained subtype if it complies with the constraints of the subtype. A variable of a constrained subtype may be implicitly converted to another subtype if it is based on the same subtype, and the constraint values are within the values of the subtype to which it is being converted.

3.2 SPL Programs

SPL is a procedural, block-structured language. There are four different types of programs that can be created using SPL, namely *procedures*, *functions*, *triggers*, and *packages*.

In addition, SPL is used to create subprograms. A *subprogram* refers to a *subprocedure* or a *subfunction*, which are nearly identical in appearance to procedures and functions, but differ in that procedures and functions are *standalone programs*, which are individually stored in the database and can be invoked by other SPL programs or from PSQL. Subprograms can only be invoked from within the standalone program with in which they have been created.

3.2.1 SPL Block Structure

Regardless of whether the program is a procedure, function, subprogram, or trigger, an SPL program has the same *block* structure. A block consists of up to three sections - an optional declaration section, a mandatory executable section, and an optional exception section. Minimally, a block has an executable section that consists of one or more SPL statements within the keywords, BEGIN and END.

The optional declaration section is used to declare variables, cursors, types, and subprograms that are used by the statements within the executable and exception sections. Declarations appear just prior to the BEGIN keyword of the executable section. Depending upon the context of where the block is used, the declaration section may begin with the keyword DECLARE.

You can include an exception section within the BEGIN - END block. The exception section begins with the keyword, EXCEPTION, and continues until the end of the block in which it appears. If an exception is thrown by a statement within the block, program control goes to the exception section where the thrown exception may or may not be handled depending upon the exception and the contents of the exception section.

The following is the general structure of a block:

```
[ [ DECLARE ]
    declarations ]
BEGIN
    statements
[ EXCEPTION
    WHEN exception_condition THEN
        statements [, ...] ]
END;
```

declarations are one or more variable, cursor, type, or subprogram declarations that are local to the block. If subprogram declarations are included, they must be declared after all other variable, cursor, and type declarations. Each declaration must be terminated by a semicolon. The use of the keyword DECLARE depends upon the context in which the block appears.

statements are one or more SPL statements. Each statement must be terminated by a semicolon. The end of the block denoted by the keyword END must also be terminated by a semicolon.

If present, the keyword EXCEPTION marks the beginning of the exception section. *exception_condition* is a conditional expression testing for one or more types of exceptions. If a thrown exception matches one of the exceptions in *exception_condition*, the *statements* following the WHEN

exception_condition clause are executed. There may be one or more WHEN *exception_condition* clauses, each followed by *statements*. **Note:** A BEGIN/END block in itself, is considered a statement; thus, blocks may be nested. The exception section may also contain nested blocks.

The following is the simplest possible block consisting of the NULL statement within the executable section. The NULL statement is an executable statement that does nothing.

```
BEGIN
    NULL;
END;
```

The following block contains a declaration section as well as the executable section.

```
DECLARE
    v_numerator      NUMBER (2);
    v_denominator   NUMBER (2);
    v_result         NUMBER (5, 2);
BEGIN
    v_numerator := 75;
    v_denominator := 14;
    v_result := v_numerator / v_denominator;
    DBMS_OUTPUT.PUT_LINE(v_numerator || ' divided by ' || v_denominator ||
                          ' is ' || v_result);
END;
```

In this example, three numeric variables are declared of data type NUMBER. Values are assigned to two of the variables, and one number is divided by the other, storing the results in a third variable which is then displayed. If executed, the output would be:

```
75 divided by 14 is 5.36
```

The following block consists of a declaration, an executable, and an exception:

```
DECLARE
    v_numerator      NUMBER (2);
    v_denominator   NUMBER (2);
    v_result         NUMBER (5, 2);
BEGIN
    v_numerator := 75;
    v_denominator := 0;
    v_result := v_numerator / v_denominator;
    DBMS_OUTPUT.PUT_LINE(v_numerator || ' divided by ' || v_denominator ||
                          ' is ' || v_result);
EXCEPTION
    WHEN OTHERS THEN
        DBMS_OUTPUT.PUT_LINE('An exception occurred');
END;
```

The following output shows that the statement within the exception section is executed as a result of the division by zero.

```
An exception occurred
```

3.2.2 Anonymous Blocks

Blocks are typically written as part of a procedure, function, subprogram, or trigger. Procedure, function, and trigger programs are named and stored in the database for re-use. For quick (one-time) execution (such as testing), you can simply enter the block without providing a name or storing it in the database.

A block of this type is called an *anonymous block*. An anonymous block is unnamed and is not stored in the database. Once the block has been executed and erased from the application buffer, it cannot be re-executed unless the block code is re-entered into the application.

Typically, the same block of code will be re-executed many times. In order to run a block of code repeatedly without the necessity of re-entering the code each time, with some simple modifications, an anonymous block can be turned into a procedure or function. The following sections discuss how to create a procedure or function that can be stored in the database and invoked repeatedly by another procedure, function, or application program.

3.2.3 Procedures Overview

Procedures are standalone SPL programs that are invoked or called as an individual SPL program statement. When called, procedures may optionally receive values from the caller in the form of input parameters and optionally return values to the caller in the form of output parameters.

3.2.3.1 Creating a Procedure

The `CREATE PROCEDURE` command defines and names a standalone procedure that will be stored in the database.

```

CREATE [OR REPLACE] PROCEDURE name [ (parameters) ]
[
    IMMUTABLE
    | STABLE
    | VOLATILE
    | DETERMINISTIC
    | [ NOT ] LEAKPROOF
    | CALLED ON NULL INPUT
    | RETURNS NULL ON NULL INPUT
    | STRICT
    | [ EXTERNAL ] SECURITY INVOKER
    | [ EXTERNAL ] SECURITY DEFINER
    | AUTHID DEFINER
    | AUTHID CURRENT_USER
    | PARALLEL { UNSAFE | RESTRICTED | SAFE }
    | COST execution_cost
    | ROWS result_rows
    | SET configuration_parameter
        { TO value | = value | FROM CURRENT }
    ...
]
{ IS | AS }
    [ declarations ]
BEGIN
    statements
END [ name ];

```

Where:

name

name is the identifier of the procedure. If you specify the `[OR REPLACE]` clause and a procedure with the same name already exists in the schema, the new procedure will replace the existing one. If you do not specify `[OR REPLACE]`, the new procedure will not replace the existing procedure with the same name in the same schema.

parameters

parameters is a list of formal parameters.

declarations

declarations are variable, cursor, type, or subprogram declarations. If subprogram declarations are included, they must be declared after all other variable, cursor, and type declarations.

statements

statements are SPL program statements (the BEGIN - END block may contain an EXCEPTION section).

IMMUTABLE

STABLE

VOLATILE

These attributes inform the query optimizer about the behavior of the procedure; you can specify only one choice. VOLATILE is the default behavior.

IMMUTABLE indicates that the procedure cannot modify the database and always reaches the same result when given the same argument values; it does not do database lookups or otherwise use information not directly present in its argument list. If you include this clause, any call of the procedure with all-constant arguments can be immediately replaced with the procedure value.

STABLE indicates that the procedure cannot modify the database, and that within a single table scan, it will consistently return the same result for the same argument values, but that its result could change across SQL statements. This is the appropriate selection for procedures that depend on database lookups, parameter variables (such as the current time zone), etc.

VOLATILE indicates that the procedure value can change even within a single table scan, so no optimizations can be made. Please note that any function that has side-effects must be classified volatile, even if its result is quite predictable, to prevent calls from being optimized away.

DETERMINISTIC

DETERMINISTIC is a synonym for IMMUTABLE. A DETERMINISTIC procedure cannot modify the database and always reaches the same result when given the same argument values; it does not do database lookups or otherwise use information not directly present in its argument list. If you include this clause, any call of the procedure with all-constant arguments can be immediately replaced with the procedure value.

[NOT] LEAKPROOF

A LEAKPROOF procedure has no side effects, and reveals no information about the values used to call the procedure.

```
CALLED ON NULL INPUT
RETURNS NULL ON NULL INPUT
STRICT
```

CALLED ON NULL INPUT (the default) indicates that the procedure will be called normally when some of its arguments are `NULL`. It is the author's responsibility to check for `NULL` values if necessary and respond appropriately.

RETURNS NULL ON NULL INPUT or STRICT indicates that the procedure always returns `NULL` whenever any of its arguments are `NULL`. If these clauses are specified, the procedure is not executed when there are `NULL` arguments; instead a `NULL` result is assumed automatically.

[EXTERNAL] SECURITY DEFINER

SECURITY DEFINER specifies that the procedure will execute with the privileges of the user that created it; this is the default. The key word EXTERNAL is allowed for SQL conformance, but is optional.

[EXTERNAL] SECURITY INVOKER

The SECURITY INVOKER clause indicates that the procedure will execute with the privileges of the user that calls it. The key word EXTERNAL is allowed for SQL conformance, but is optional.

```
AUTHID DEFINER
AUTHID CURRENT_USER
```

The AUTHID DEFINER clause is a synonym for [EXTERNAL] SECURITY DEFINER. If the AUTHID clause is omitted or if AUTHID DEFINER is specified, the rights of the procedure owner are used to determine access privileges to database objects.

The AUTHID CURRENT_USER clause is a synonym for [EXTERNAL] SECURITY INVOKER. If AUTHID CURRENT_USER is specified, the rights of the current user executing the procedure are used to determine access privileges.

```
PARALLEL { UNSAFE | RESTRICTED | SAFE }
```

The `PARALLEL` clause enables the use of parallel sequential scans (parallel mode). A parallel sequential scan uses multiple workers to scan a relation in parallel during a query in contrast to a serial sequential scan.

When set to `UNSAFE`, the procedure cannot be executed in parallel mode. The presence of such a procedure forces a serial execution plan. This is the default setting if the `PARALLEL` clause is omitted.

When set to `RESTRICTED`, the procedure can be executed in parallel mode, but the execution is restricted to the parallel group leader. If the qualification for any particular relation has anything that is parallel restricted, that relation won't be chosen for parallelism.

When set to `SAFE`, the procedure can be executed in parallel mode with no restriction.

`COST execution_cost`

`execution_cost` is a positive number giving the estimated execution cost for the procedure, in units of `cpu_operator_cost`. If the procedure returns a set, this is the cost per returned row. Larger values cause the planner to try to avoid evaluating the function more often than necessary.

`ROWS result_rows`

`result_rows` is a positive number giving the estimated number of rows that the planner should expect the procedure to return. This is only allowed when the procedure is declared to return a set. The default assumption is 1000 rows.

`SET configuration_parameter { TO value | = value | FROM CURRENT }`

The `SET` clause causes the specified configuration parameter to be set to the specified value when the procedure is entered, and then restored to its prior value when the procedure exits. `SET FROM CURRENT` saves the session's current value of the parameter as the value to be applied when the procedure is entered.

If a `SET` clause is attached to a procedure, then the effects of a `SET LOCAL` command executed inside the procedure for the same variable are restricted to the procedure; the configuration parameter's prior value is restored at procedure exit. An ordinary `SET` command (without `LOCAL`) overrides the `SET` clause, much as it would do for a previous `SET LOCAL` command, with the effects of such a command persisting after procedure exit, unless the current transaction is rolled back.

Please Note: The `STRICT`, `LEAKPROOF`, `PARALLEL`, `COST`, `ROWS` and `SET` keywords provide extended functionality for Advanced Server and are not supported by Oracle.

Example

The following is an example of a simple procedure that takes no parameters.

```
CREATE OR REPLACE PROCEDURE simple_procedure
IS
BEGIN
    DBMS_OUTPUT.PUT_LINE('That''s all folks!');
END simple_procedure;
```

The procedure is stored in the database by entering the procedure code in Advanced Server.

The following example demonstrates using the `AUTHID DEFINER` and `SET` clauses in a procedure declaration. The `update_salary` procedure conveys the privileges of the role that defined the procedure to the role that is calling the procedure (while the procedure executes):

```
CREATE OR REPLACE PROCEDURE update_salary(id INT, new_salary NUMBER)
    SET SEARCH_PATH = 'public' SET WORK_MEM = '1MB'
    AUTHID DEFINER IS
BEGIN
    UPDATE emp SET salary = new_salary WHERE emp_id = id;
END;
```

Include the `SET` clause to set the procedure's search path to `public` and the work memory to `1MB`. Other procedures, functions and objects will not be affected by these settings.

In this example, the `AUTHID DEFINER` clause temporarily grants privileges to a role that might otherwise not be allowed to execute the statements within the procedure. To instruct the server to use the privileges associated with the role invoking the procedure, replace the `AUTHID DEFINER` clause with the `AUTHID CURRENT_USER` clause.

3.2.3.2 Calling a Procedure

A procedure can be invoked from another SPL program by simply specifying the procedure name followed by its parameters, if any, followed by a semicolon.

name [([*parameters*])] ;

Where:

name is the identifier of the procedure.

parameters is a list of actual parameters.

Note: If there are no actual parameters to be passed, the procedure may be called with an empty parameter list, or the opening and closing parenthesis may be omitted entirely.

Note: The syntax for calling a procedure is the same as in the preceding syntax diagram when executing it with the EXEC command in PSQL or EDB*Plus. See the *Database Compatibility for Oracle Developers Tools and Utilities Guide* for information about the EXEC command.

The following is an example of calling the procedure from an anonymous block:

```
BEGIN
    simple_procedure;
END;

That's all folks!
```

Note: Each application has its own unique way to call a procedure. For example, in a Java application, the application programming interface, JDBC, is used.

3.2.3.3 Deleting a Procedure

A procedure can be deleted from the database using the DROP PROCEDURE command.

```
DROP PROCEDURE name;
```

Where *name* is the name of the procedure to be dropped.

The previously created procedure is dropped in this example:

```
DROP PROCEDURE simple_procedure;
```

3.2.4 Functions Overview

Functions are standalone SPL programs that are invoked as expressions. When evaluated, a function returns a value that is substituted in the expression in which the function is embedded. Functions may optionally take values from the calling program in the form of input parameters. In addition to the fact that the function, itself, returns a value, a function may optionally return additional values to the caller in the form of output parameters. The use of output parameters in functions, however, is not an encouraged programming practice.

3.2.4.1 Creating a Function

The `CREATE FUNCTION` command defines and names a standalone function that will be stored in the database.

```

CREATE [ OR REPLACE ] FUNCTION name [ (parameters) ]
    RETURN data_type
    [
        IMMUTABLE
        | STABLE
        | VOLATILE
        | DETERMINISTIC
        | [ NOT ] LEAKPROOF
        | CALLED ON NULL INPUT
        | RETURNS NULL ON NULL INPUT
        | STRICT
        | [ EXTERNAL ] SECURITY INVOKER
        | [ EXTERNAL ] SECURITY DEFINER
        | AUTHID DEFINER
        | AUTHID CURRENT_USER
        | PARALLEL { UNSAFE | RESTRICTED | SAFE }
        | COST execution_cost
        | ROWS result_rows
        | SET configuration_parameter
            { TO value | = value | FROM CURRENT }
        ...
    ]
    { IS | AS }
        [ declarations ]
    BEGIN
        statements
    END [ name ];

```

Where:

name

name is the identifier of the function. If you specify the [OR REPLACE] clause and a function with the same name already exists in the schema, the new function will replace the existing one. If you do not specify [OR REPLACE], the new function will not replace the existing function with the same name in the same schema.

parameters

parameters is a list of formal parameters.

data_type

data_type is the data type of the value returned by the function's RETURN statement.

declarations

declarations are variable, cursor, type, or subprogram declarations. If subprogram declarations are included, they must be declared after all other variable, cursor, and type declarations.

statements

statements are SPL program statements (the BEGIN-END block may contain an EXCEPTION section).

IMMUTABLE
STABLE
VOLATILE

These attributes inform the query optimizer about the behavior of the function; you can specify only one choice. VOLATILE is the default behavior.

IMMUTABLE indicates that the function cannot modify the database and always reaches the same result when given the same argument values; it does not do database lookups or otherwise use information not directly present in its argument list. If you include this clause, any call of the function with all-constant arguments can be immediately replaced with the function value.

STABLE indicates that the function cannot modify the database, and that within a single table scan, it will consistently return the same result for the same argument values, but that its result could change across SQL statements. This is the appropriate selection for function that depend on database lookups, parameter variables (such as the current time zone), etc.

`VOLATILE` indicates that the function value can change even within a single table scan, so no optimizations can be made. Please note that any function that has side-effects must be classified volatile, even if its result is quite predictable, to prevent calls from being optimized away.

DETERMINISTIC

`DETERMINISTIC` is a synonym for `IMMUTABLE`. A `DETERMINISTIC` function cannot modify the database and always reaches the same result when given the same argument values; it does not do database lookups or otherwise use information not directly present in its argument list. If you include this clause, any call of the function with all-constant arguments can be immediately replaced with the function value.

[NOT] LEAKPROOF

A `LEAKPROOF` function has no side effects, and reveals no information about the values used to call the function.

```
CALLED ON NULL INPUT
RETURNS NULL ON NULL INPUT
STRICT
```

`CALLED ON NULL INPUT` (the default) indicates that the procedure will be called normally when some of its arguments are `NULL`. It is the author's responsibility to check for `NULL` values if necessary and respond appropriately.

`RETURNS NULL ON NULL INPUT` or `STRICT` indicates that the procedure always returns `NULL` whenever any of its arguments are `NULL`. If these clauses are specified, the procedure is not executed when there are `NULL` arguments; instead a `NULL` result is assumed automatically.

[EXTERNAL] SECURITY DEFINER

`SECURITY DEFINER` specifies that the function will execute with the privileges of the user that created it; this is the default. The key word `EXTERNAL` is allowed for SQL conformance, but is optional.

[EXTERNAL] SECURITY INVOKER

The `SECURITY INVOKER` clause indicates that the function will execute with the privileges of the user that calls it. The key word `EXTERNAL` is allowed for SQL conformance, but is optional.

```
AUTHID DEFINER
AUTHID CURRENT_USER
```

The AUTHID DEFINER clause is a synonym for [EXTERNAL] SECURITY DEFINER. If the AUTHID clause is omitted or if AUTHID DEFINER is specified, the rights of the function owner are used to determine access privileges to database objects.

The AUTHID CURRENT_USER clause is a synonym for [EXTERNAL] SECURITY INVOKER. If AUTHID CURRENT_USER is specified, the rights of the current user executing the function are used to determine access privileges.

`PARALLEL { UNSAFE | RESTRICTED | SAFE }`

The PARALLEL clause enables the use of parallel sequential scans (parallel mode). A parallel sequential scan uses multiple workers to scan a relation in parallel during a query in contrast to a serial sequential scan.

When set to UNSAFE, the function cannot be executed in parallel mode. The presence of such a function in a SQL statement forces a serial execution plan. This is the default setting if the PARALLEL clause is omitted.

When set to RESTRICTED, the function can be executed in parallel mode, but the execution is restricted to the parallel group leader. If the qualification for any particular relation has anything that is parallel restricted, that relation won't be chosen for parallelism.

When set to SAFE, the function can be executed in parallel mode with no restriction.

`COST execution_cost`

execution_cost is a positive number giving the estimated execution cost for the function, in units of `cpu_operator_cost`. If the function returns a set, this is the cost per returned row. Larger values cause the planner to try to avoid evaluating the function more often than necessary.

`ROWS result_rows`

result_rows is a positive number giving the estimated number of rows that the planner should expect the function to return. This is only allowed when the function is declared to return a set. The default assumption is 1000 rows.

`SET configuration_parameter { TO value | = value | FROM CURRENT }`

The SET clause causes the specified configuration parameter to be set to the specified value when the function is entered, and then restored to its prior value when the function exits. SET FROM CURRENT saves the session's current value of the parameter as the value to be applied when the function is entered.

If a `SET` clause is attached to a function, then the effects of a `SET LOCAL` command executed inside the function for the same variable are restricted to the function; the configuration parameter's prior value is restored at function exit. An ordinary `SET` command (without `LOCAL`) overrides the `SET` clause, much as it would do for a previous `SET LOCAL` command, with the effects of such a command persisting after procedure exit, unless the current transaction is rolled back.

Please Note: The `STRICT`, `LEAKPROOF`, `PARALLEL`, `COST`, `ROWS` and `SET` keywords provide extended functionality for Advanced Server and are not supported by Oracle.

Examples

The following is an example of a simple function that takes no parameters.

```
CREATE OR REPLACE FUNCTION simple_function
    RETURN VARCHAR2
IS
BEGIN
    RETURN 'That''s All Folks!';
END simple_function;
```

The following function takes two input parameters. Parameters are discussed in more detail in subsequent sections.

```
CREATE OR REPLACE FUNCTION emp_comp (
    p_sal          NUMBER,
    p_comm         NUMBER
) RETURN NUMBER
IS
BEGIN
    RETURN (p_sal + NVL(p_comm, 0)) * 24;
END emp_comp;
```

The following example demonstrates using the `AUTHID CURRENT_USER` clause and `STRICT` keyword in a function declaration:

```
CREATE OR REPLACE FUNCTION dept_salaries(dept_id int) RETURN NUMBER
    STRICT
    AUTHID CURRENT_USER
BEGIN
    RETURN QUERY (SELECT sum(salary) FROM emp WHERE deptno = id);
END;
```

Include the `STRICT` keyword to instruct the server to return `NULL` if any input parameter passed is `NULL`; if a `NULL` value is passed, the function will not execute.

The `dept_salaries` function executes with the privileges of the role that is calling the function. If the current user does not have sufficient privileges to perform the `SELECT` statement querying the `emp` table (to display employee salaries), the function will report an error. To instruct the server to use the privileges associated with the role that defined

the function, replace the AUTHID CURRENT_USER clause with the AUTHID DEFINER clause.

3.2.4.2 Calling a Function

A function can be used anywhere an expression can appear within an SPL statement. A function is invoked by simply specifying its name followed by its parameters enclosed in parenthesis, if any.

```
name [ ([ parameters ]) ]
```

name is the name of the function. *parameters* is a list of actual parameters.

Note: If there are no actual parameters to be passed, the function may be called with an empty parameter list, or the opening and closing parenthesis may be omitted entirely.

The following shows how the function can be called from another SPL program.

```
BEGIN
    DBMS_OUTPUT.PUT_LINE(simple_function);
END;

That's All Folks!
```

A function is typically used within a SQL statement as shown in the following.

```
SELECT empno "EMPNO", ename "ENAME", sal "SAL", comm "COMM",
       emp_comp(sal, comm) "YEARLY COMPENSATION" FROM emp;
```

EMPNO	ENAME	SAL	COMM	YEARLY COMPENSATION
7369	SMITH	800.00		19200.00
7499	ALLEN	1600.00	300.00	45600.00
7521	WARD	1250.00	500.00	42000.00
7566	JONES	2975.00		71400.00
7654	MARTIN	1250.00	1400.00	63600.00
7698	BLAKE	2850.00		68400.00
7782	CLARK	2450.00		58800.00
7788	SCOTT	3000.00		72000.00
7839	KING	5000.00		120000.00
7844	TURNER	1500.00	0.00	36000.00
7876	ADAMS	1100.00		26400.00
7900	JAMES	950.00		22800.00
7902	FORD	3000.00		72000.00
7934	MILLER	1300.00		31200.00

(14 rows)

3.2.4.3 Deleting a Function

A function can be deleted from the database using the `DROP FUNCTION` command.

```
DROP FUNCTION name [ (parameters) ];
```

Where `name` is the name of the function to be dropped.

Note: The specification of the parameter list is required in Advanced Server under certain circumstances. Oracle requires that the parameter list always be omitted.

The previously created function is dropped in this example:

```
DROP FUNCTION simple_function;
```

3.2.5 Procedure and Function Parameters

An important aspect of using procedures and functions is the capability to pass data from the calling program to the procedure or function and to receive data back from the procedure or function. This is accomplished by using *parameters*.

Parameters are declared in the procedure or function definition, enclosed within parenthesis following the procedure or function name. Parameters declared in the procedure or function definition are known as *formal parameters*. When the procedure or function is invoked, the calling program supplies the actual data that is to be used in the called program's processing as well as the variables that are to receive the results of the called program's processing. The data and variables supplied by the calling program when the procedure or function is called are referred to as the *actual parameters*.

The following is the general format of a formal parameter declaration.

```
(name [ IN | OUT | IN OUT ] data_type [ DEFAULT value ])
```

name is an identifier assigned to the formal parameter. If specified, *IN* defines the parameter for receiving input data into the procedure or function. An *IN* parameter can also be initialized to a default value. If specified, *OUT* defines the parameter for returning data from the procedure or function. If specified, *IN OUT* allows the parameter to be used for both input and output. If all of *IN*, *OUT*, and *IN OUT* are omitted, then the parameter acts as if it were defined as *IN* by default. Whether a parameter is *IN*, *OUT*, or *IN OUT* is referred to as the parameter's *mode*. *data_type* defines the datatype of the parameter. *value* is a default value assigned to an *IN* parameter in the called program if an actual parameter is not specified in the call.

The following is an example of a procedure that takes parameters:

```
CREATE OR REPLACE PROCEDURE emp_query (
    p_deptno      IN      NUMBER,
    p_empno       IN OUT NUMBER,
    p_ename        IN OUT VARCHAR2,
    p_job          OUT     VARCHAR2,
    p_hiredate    OUT     DATE,
    p_sal          OUT     NUMBER
)
IS
BEGIN
    SELECT empno, ename, job, hiredate, sal
        INTO p_empno, p_ename, p_job, p_hiredate, p_sal
        FROM emp
        WHERE deptno = p_deptno
            AND (empno = p_empno
                OR ename = UPPER(p_ename));
END;
```

In this example, `p_deptno` is an `IN` formal parameter, `p_empno` and `p_ename` are `IN OUT` formal parameters, and `p_job`, `p_hiredate`, and `p_sal` are `OUT` formal parameters.

Note: In the previous example, no maximum length was specified on the `VARCHAR2` parameters and no precision and scale were specified on the `NUMBER` parameters. It is illegal to specify a length, precision, scale or other constraints on parameter declarations. These constraints are automatically inherited from the actual parameters that are used when the procedure or function is called.

The `emp_query` procedure can be called by another program, passing it the actual parameters. The following is an example of another SPL program that calls `emp_query`.

```

DECLARE
    v_deptno      NUMBER(2);
    v_empno       NUMBER(4);
    v_ename        VARCHAR2(10);
    v_job          VARCHAR2(9);
    v_hiredate     DATE;
    v_sal          NUMBER;
BEGIN
    v_deptno := 30;
    v_empno  := 7900;
    v_ename   := '';
    emp_query(v_deptno, v_empno, v_ename, v_job, v_hiredate, v_sal);
    DBMS_OUTPUT.PUT_LINE('Department : ' || v_deptno);
    DBMS_OUTPUT.PUT_LINE('Employee No: ' || v_empno);
    DBMS_OUTPUT.PUT_LINE('Name      : ' || v_ename);
    DBMS_OUTPUT.PUT_LINE('Job       : ' || v_job);
    DBMS_OUTPUT.PUT_LINE('Hire Date : ' || v_hiredate);
    DBMS_OUTPUT.PUT_LINE('Salary    : ' || v_sal);
END;

```

In this example, `v_deptno`, `v_empno`, `v_ename`, `v_job`, `v_hiredate`, and `v_sal` are the actual parameters.

The output from the preceding example is shown as follows:

```

Department : 30
Employee No: 7900
Name      : JAMES
Job       : CLERK
Hire Date : 03-DEC-81
Salary    : 950

```

3.2.5.1 Positional vs. Named Parameter Notation

You can use either *positional* or *named* parameter notation when passing parameters to a function or procedure. If you specify parameters using positional notation, you must list the parameters in the order that they are declared; if you specify parameters with named notation, the order of the parameters is not significant.

To specify parameters using named notation, list the name of each parameter followed by an arrow ($=>$) and the parameter value. Named notation is more verbose, but makes your code easier to read and maintain.

A simple example that demonstrates using positional and named parameter notation follows:

```
CREATE OR REPLACE PROCEDURE emp_info (
    p_deptno      IN      NUMBER,
    p_empno       IN OUT NUMBER,
    p_ename        IN OUT VARCHAR2,
)
IS
BEGIN
    dbms_output.put_line('Department Number =' || p_deptno);
    dbms_output.put_line('Employee Number =' || p_empno);
    dbms_output.put_line('Employee Name =' || p_ename);
END;
```

To call the procedure using positional notation, pass the following:

```
emp_info(30, 7455, 'Clark');
```

To call the procedure using named notation, pass the following:

```
emp_info(p_ename =>'Clark', p_empno=>7455, p_deptno=>30);
```

Using named notation can alleviate the need to re-arrange a procedure's parameter list if the parameter list changes, if the parameters are reordered or if a new optional parameter is added.

In a case where you have a default value for an argument and the argument is not a trailing argument, you must use named notation to call the procedure or function. The following case demonstrates a procedure with two, leading, default arguments.

```
CREATE OR REPLACE PROCEDURE check_balance (
    p_customerID  IN NUMBER DEFAULT NULL,
    p_balance      IN NUMBER DEFAULT NULL,
    p_amount       IN NUMBER
)
IS
DECLARE
    balance NUMBER;
BEGIN
    IF (p_balance IS NULL AND p_customerID IS NULL) THEN
        RAISE_APPLICATION_ERROR
            (-20010, 'Must provide balance or customer');
    ELSEIF (p_balance IS NOT NULL AND p_customerID IS NOT NULL) THEN
        RAISE_APPLICATION_ERROR
            (-20020, 'Must provide balance or customer, not both');
    ELSEIF (p_balance IS NULL) THEN
```

```

        balance := getCustomerBalance(p_customerID);
ELSE
    balance := p_balance;
END IF;

IF (amount > balance) THEN
    RAISE_APPLICATION_ERROR
        (-20030, 'Balance insufficient');
END IF;
END;

```

You can only omit non-trailing argument values (when you call this procedure) by using named notation; when using positional notation, only trailing arguments are allowed to default. You can call this procedure with the following arguments:

```

check_balance(p_customerID => 10, p_amount = 500.00)

check_balance(p_balance => 1000.00, p_amount = 500.00)

```

You can use a combination of positional and named notation (mixed notation) to specify parameters. A simple example that demonstrates using mixed parameter notation follows:

```

CREATE OR REPLACE PROCEDURE emp_info (
    p_deptno          IN      NUMBER,
    p_empno           IN OUT NUMBER,
    p_ename            IN OUT VARCHAR2,
)
IS
BEGIN
    dbms_output.put_line('Department Number =' || p_deptno);
    dbms_output.put_line('Employee Number =' || p_empno);
    dbms_output.put_line('Employee Name =' || p_ename);
END;

```

You can call the procedure using mixed notation:

```
emp_info(30, p_ename =>'Clark', p_empno=>7455);
```

If you do use mixed notation, remember that named arguments cannot precede positional arguments.

3.2.5.2 Parameter Modes

As previously discussed, a parameter has one of three possible modes - `IN`, `OUT`, or `IN OUT`. The following characteristics of a formal parameter are dependent upon its mode:

- Its initial value when the procedure or function is called.
- Whether or not the called procedure or function can modify the formal parameter.

- How the actual parameter value is passed from the calling program to the called program.
- What happens to the formal parameter value when an unhandled exception occurs in the called program.

The following table summarizes the behavior of parameters according to their mode.

Table 3-1 Parameter Modes

Mode Property	IN	IN OUT	OUT
Formal parameter initialized to:	Actual parameter value	Actual parameter value	Actual parameter value
Formal parameter modifiable by the called program?	No	Yes	Yes
Actual parameter contains: (after normal called program termination)	Original actual parameter value prior to the call	Last value of the formal parameter	Last value of the formal parameter
Actual parameter contains: (after a handled exception in the called program)	Original actual parameter value prior to the call	Last value of the formal parameter	Last value of the formal parameter
Actual parameter contains: (after an unhandled exception in the called program)	Original actual parameter value prior to the call	Original actual parameter value prior to the call	Original actual parameter value prior to the call

As shown by the table, an `IN` formal parameter is initialized to the actual parameter with which it is called unless it was explicitly initialized with a default value. The `IN` parameter may be referenced within the called program, however, the called program may not assign a new value to the `IN` parameter. After control returns to the calling program, the actual parameter always contains the same value as it was set to prior to the call.

The `OUT` formal parameter is initialized to the actual parameter with which it is called. The called program may reference and assign new values to the formal parameter. If the called program terminates without an exception, the actual parameter takes on the value last set in the formal parameter. If a handled exception occurs, the value of the actual parameter takes on the last value assigned to the formal parameter. If an unhandled exception occurs, the value of the actual parameter remains as it was prior to the call.

Like an `IN` parameter, an `IN OUT` formal parameter is initialized to the actual parameter with which it is called. Like an `OUT` parameter, an `IN OUT` formal parameter is modifiable by the called program and the last value in the formal parameter is passed to the calling program's actual parameter if the called program terminates without an exception. If a handled exception occurs, the value of the actual parameter takes on the last value assigned to the formal parameter. If an unhandled exception occurs, the value of the actual parameter remains as it was prior to the call.

3.2.5.3 Using Default Values in Parameters

You can set a default value of a formal parameter by including the `DEFAULT` clause or using the assignment operator (`:=`) in the `CREATE PROCEDURE` or `CREATE FUNCTION` statement.

The general form of a formal parameter declaration is:

```
(name [ IN|OUT|IN OUT ] data_type [{DEFAULT | := } expr ])
```

name is an identifier assigned to the parameter.

`IN|OUT|IN OUT` specifies the parameter mode.

data_type is the data type assigned to the variable.

expr is the default value assigned to the parameter. If you do not include a `DEFAULT` clause, the caller must provide a value for the parameter.

The default value is evaluated every time the function or procedure is invoked. For example, assigning `SYSDATE` to a parameter of type `DATE` causes the parameter to have the time of the current invocation, not the time when the procedure or function was created.

The following simple procedure demonstrates using the assignment operator to set a default value of `SYSDATE` into the parameter, `hiredate`:

```
CREATE OR REPLACE PROCEDURE hire_emp (
    p_empno        NUMBER,
    p_ename        VARCHAR2,
    p_hiredate     DATE := SYSDATE
)
IS
BEGIN
    INSERT INTO emp(empno, ename, hiredate)
        VALUES(p_empno, p_ename, p_hiredate);

    DBMS_OUTPUT.PUT_LINE('Hired!');
END hire_emp;
```

If the parameter declaration includes a default value, you can omit the parameter from the actual parameter list when you call the procedure. Calls to the sample procedure (`hire_emp`) must include two arguments: the employee number (`p_empno`) and employee name (`p_ename`). The third parameter (`p_hiredate`) defaults to the value of `SYSDATE`:

```
hire_emp (7575, Clark)
```

If you do include a value for the actual parameter when you call the procedure, that value takes precedence over the default value:

```
hire_emp (7575, Clark, 15-FEB-2010)
```

Adds a new employee with a hiredate of February 15, 2010, regardless of the current value of SYSDATE.

You can write the same procedure by substituting the `DEFAULT` keyword for the assignment operator:

```
CREATE OR REPLACE PROCEDURE hire_emp (
    p_empno          NUMBER,
    p_ename          VARCHAR2,
    p_hiredate       DATE DEFAULT SYSDATE
)
IS
BEGIN
    INSERT INTO emp(empno, ename, hiredate)
        VALUES(p_empno, p_ename, p_hiredate);

    DBMS_OUTPUT.PUT_LINE('Hired!');
END hire_emp;
```

3.2.6 Subprograms – Subprocedures and Subfunctions

The capability and functionality of SPL procedure and function programs can be used in an advantageous manner to build well-structured and maintainable programs by organizing the SPL code into subprocedures and subfunctions.

The same SPL code can be invoked multiple times from different locations within a relatively large SPL program by declaring subprocedures and subfunctions within the SPL program.

Subprocedures and subfunctions have the following characteristics:

- The syntax, structure, and functionality of subprocedures and subfunctions are practically identical to standalone procedures and functions. The major difference is the use of the keyword `PROCEDURE` or `FUNCTION` instead of `CREATE PROCEDURE` or `CREATE FUNCTION` to declare the subprogram.
- Subprocedures and subfunctions provide isolation for the identifiers (that is, variables, cursors, types, and other subprograms) declared within itself. That is, these identifiers cannot be accessed nor altered from the upper, parent level SPL programs or subprograms outside of the subprocedure or subfunction. This ensures that the subprocedure and subfunction results are reliable and predictable.
- The declaration section of subprocedures and subfunctions can include its own subprocedures and subfunctions. Thus, a multi-level hierarchy of subprograms

can exist in the standalone program. Within the hierarchy, a subprogram can access the identifiers of upper level parent subprograms and also invoke upper level parent subprograms. However, the same access to identifiers and invocation cannot be done for lower level child subprograms in the hierarchy.

Subprocedures and subfunctions can be declared and invoked from within any of the following types of SPL programs:

- Standalone procedures and functions
- Anonymous blocks
- Triggers
- Packages
- Procedure and function methods of an object type body
- Subprocedures and subfunctions declared within any of the preceding programs

The rules regarding subprocedure and subfunction structure and access are discussed in more detail in the next sections.

3.2.6.1 Creating a Subprocedure

The `PROCEDURE` clause specified in the declaration section defines and names a subprocedure local to that block.

The term *block* refers to the SPL block structure consisting of an optional declaration section, a mandatory executable section, and an optional exception section. Blocks are the structures for standalone procedures and functions, anonymous blocks, subprograms, triggers, packages, and object type methods.

The phrase *the identifier is local to the block* means that the identifier (that is, a variable, cursor, type, or subprogram) is declared within the declaration section of that block and is therefore accessible by the SPL code within the executable section and optional exception section of that block.

Subprocedures can only be declared after all other variable, cursor, and type declarations included in the declaration section. (That is, subprograms must be the last set of declarations.)

```
PROCEDURE name [ (parameters) ]
{ IS | AS }
[ declarations ]
BEGIN
  statements
END [ name ];
```

Where:

*name**name* is the identifier of the subprocedure.*parameters**parameters* is a list of formal parameters.*declarations**declarations* are variable, cursor, type, or subprogram declarations. If subprogram declarations are included, they must be declared after all other variable, cursor, and type declarations.*statements**statements* are SPL program statements (the BEGIN - END block may contain an EXCEPTION section).

Examples

The following example is a subprocedure within an anonymous block.

```

DECLARE
    PROCEDURE list_emp
    IS
        v_empno      NUMBER(4);
        v_ename      VARCHAR2(10);
        CURSOR emp_cur IS
            SELECT empno, ename FROM emp ORDER BY empno;
    BEGIN
        OPEN emp_cur;
        DBMS_OUTPUT.PUT_LINE('Subprocedure list_emp:');
        DBMS_OUTPUT.PUT_LINE('EMPNO    ENAME');
        DBMS_OUTPUT.PUT_LINE('-----  -----');
        LOOP
            FETCH emp_cur INTO v_empno, v_ename;
            EXIT WHEN emp_cur%NOTFOUND;
            DBMS_OUTPUT.PUT_LINE(v_empno || '    ' || v_ename);
        END LOOP;
        CLOSE emp_cur;
    END;
BEGIN
    list_emp;
END;

```

Invoking this anonymous block produces the following output:

```

Subprocedure list_emp:
EMPNO    ENAME
-----
7369     SMITH
7499     ALLEN
7521     WARD

```

```

7566      JONES
7654      MARTIN
7698      BLAKE
7782      CLARK
7788      SCOTT
7839      KING
7844      TURNER
7876      ADAMS
7900      JAMES
7902      FORD
7934      MILLER

```

The following example is a subprocedure within a trigger.

```

CREATE OR REPLACE TRIGGER dept_audit_trig
    AFTER INSERT OR UPDATE OR DELETE ON dept
DECLARE
    v_action          VARCHAR2(24);
    PROCEDURE display_action (
        p_action      IN VARCHAR2
    )
    IS
    BEGIN
        DBMS_OUTPUT.PUT_LINE('User ' || USER || ' ' || p_action ||
            ' dept on ' || TO_CHAR(SYSDATE,'YYYY-MM-DD'));
    END display_action;
BEGIN
    IF INSERTING THEN
        v_action := 'added';
    ELSIF UPDATING THEN
        v_action := 'updated';
    ELSIF DELETING THEN
        v_action := 'deleted';
    END IF;
    display_action(v_action);
END;

```

Invoking this trigger produces the following output:

```

INSERT INTO dept VALUES (50, 'HR', 'DENVER');

User enterprisedb added dept on 2016-07-26

```

3.2.6.2 Creating a Subfunction

The `FUNCTION` clause specified in the declaration section defines and names a subfunction local to that block.

The term *block* refers to the SPL block structure consisting of an optional declaration section, a mandatory executable section, and an optional exception section. Blocks are the structures for standalone procedures and functions, anonymous blocks, subprograms, triggers, packages, and object type methods.

The phrase *the identifier is local to the block* means that the identifier (that is, a variable, cursor, type, or subprogram) is declared within the declaration section of that block and is therefore accessible by the SPL code within the executable section and optional exception section of that block.

```
FUNCTION name [ (parameters) ]
RETURN data_type
{ IS | AS }
[ declarations ]
BEGIN
statements
END [ name ];
```

Where:

name

name is the identifier of the subfunction.

parameters

parameters is a list of formal parameters.

data_type

data_type is the data type of the value returned by the function's RETURN statement.

declarations

declarations are variable, cursor, type, or subprogram declarations. If subprogram declarations are included, they must be declared after all other variable, cursor, and type declarations.

statements

statements are SPL program statements (the BEGIN - END block may contain an EXCEPTION section).

Examples

The following example shows the use of a recursive subfunction:

```
DECLARE
  FUNCTION factorial (
    n          BINARY_INTEGER
  ) RETURN BINARY_INTEGER
  IS
  BEGIN
```

```

IF n = 1 THEN
    RETURN n;
ELSE
    RETURN n * factorial(n-1);
END IF;
END factorial;
BEGIN
FOR i IN 1..5 LOOP
    DBMS_OUTPUT.PUT_LINE(i || '! = ' || factorial(i));
END LOOP;
END;

```

The output from the example is the following:

```

1! = 1
2! = 2
3! = 6
4! = 24
5! = 120

```

3.2.6.3 Block Relationships

This section describes the terminology of the relationship between blocks that can be declared in an SPL program. The ability to invoke subprograms and access identifiers declared within a block depends upon this relationship.

The following are the basic terms:

- A *block* is the basic SPL structure consisting of an optional declaration section, a mandatory executable section, and an optional exception section. Blocks implement standalone procedure and function programs, anonymous blocks, triggers, packages, and subprocedures and subfunctions.
- An identifier (variable, cursor, type, or subprogram) *local to a block* means that it is declared within the declaration section of the given block. Such local identifiers are accessible from the executable section and optional exception section of the block.
- The *parent block* contains the declaration of another block (the *child block*).
- *Descendent blocks* are the set of blocks forming the child relationship starting from a given parent block.
- *Ancestor blocks* are the set of blocks forming the parental relationship starting from a given child block.
- The set of descendent (or ancestor) blocks form a *hierarchy*.
- The *level* is an ordinal number of a given block from the highest, ancestor block. For example, given a standalone procedure, the subprograms declared within the declaration section of this procedure are all at the same level, for example call it level 1. Additional subprograms within the declaration section of the subprograms declared in the standalone procedure are at the next level, which is level 2.

- The *sibling blocks* are the set of blocks that have the same parent block (that is, they are all locally declared in the same block). Sibling blocks are also always at the same level relative to each other.

The following schematic of a set of procedure declaration sections provides an example of a set of blocks and their relationships to their surrounding blocks.

The two vertical lines on the left-hand side of the blocks indicate there are two pairs of sibling blocks. `block_1a` and `block_1b` is one pair, and `block_2a` and `block_2b` is the second pair.

The relationship of each block with its ancestors is shown on the right-hand side of the blocks. There are three hierarchical paths formed when progressing up the hierarchy from the lowest level child blocks. The first consists of `block_0`, `block_1a`, `block_2a`, and `block_3`. The second is `block_0`, `block_1a`, and `block_2b`. The third is `block_0`, `block_1b`, and `block_2b`.

```

CREATE PROCEDURE block_0
IS
    PROCEDURE block_1a      ----- Local to block_0
    IS
        .
        .
        .
    PROCEDURE block_2a      ---- Local to block_1a and descendant
    IS
        .
        .
        .
    |     PROCEDURE block_3   -- Local to block_2a and descendant
    |     IS
        .
        .
        .
    |     END block_3;
    |     END block_2a;
    PROCEDURE block_1b;      ----- Local to block_0
    IS
        .
        .
        .
    |     PROCEDURE block_2b   ---- Local to block_1b and descendant
    |     IS
        .
        .
        .
    |     END block_2b;
    |     .
    |     .
    |     .
    BEGIN
        .
        .
        .
    END block_0;

```

The rules for invoking subprograms based upon block location is described starting with Section [3.2.6.4](#). The rules for accessing variables based upon block location is described in Section [3.2.6.7](#).

3.2.6.4 Invoking Subprograms

A subprogram is invoked in the same manner as a standalone procedure or function by specifying its name and any actual parameters.

The subprogram may be invoked with none, one, or more qualifiers, which are the names of the parent subprograms or labeled anonymous blocks forming the ancestor hierarchy from where the subprogram has been declared.

The invocation is specified as a dot-separated list of qualifiers ending with the subprogram name and any of its arguments as shown by the following:

```
[ [qualifier_1.] [...] qualifier_n.] subprog [(arguments)]
```

If specified, *qualifier_n* is the subprogram in which *subprog* has been declared in its declaration section. The preceding list of qualifiers must reside in a continuous path up the hierarchy from *qualifier_n* to *qualifier_1*. *qualifier_1* may be any ancestor subprogram in the path as well as any of the following:

- Standalone procedure name containing the subprogram
- Standalone function name containing subprogram
- Package name containing the subprogram
- Object type name containing the subprogram within an object type method
- An anonymous block label included prior to the `DECLARE` keyword if a declaration section exists, or prior to the `BEGIN` keyword if there is no declaration section.

Note: *qualifier_1* may not be a schema name, otherwise an error is thrown upon invocation of the subprogram. This Advanced Server restriction is not compatible with Oracle databases, which allow use of the schema name as a qualifier.

arguments is the list of actual parameters to be passed to the subprocedure or subfunction.

Upon invocation, the search for the subprogram occurs as follows:

- The invoked subprogram name of its type (that is, subprocedure or subfunction) along with any qualifiers in the specified order, (referred to as the invocation list) is used to find a matching set of blocks residing in the same hierarchical order. The search begins in the block hierarchy where the lowest level is the block from where the subprogram is invoked. The declaration of the subprogram must be in the SPL code prior to the code line where it is invoked when the code is observed from top to bottom. (An exception to this requirement can be accomplished using a forward declaration. See Section [3.2.6.5](#) for information on forward declarations.)
- If the invocation list does not match the hierarchy of blocks starting from the block where the subprogram is invoked, a comparison is made by matching the invocation list starting with the parent of the previous starting block. In other words, the comparison progresses up the hierarchy.
- If there are sibling blocks of the ancestors, the invocation list comparison also includes the hierarchy of the sibling blocks, but always comparing in an upward level, never comparing the descendants of the sibling blocks.
- This comparison process continues up the hierarchies until the first complete match is found in which case the located subprogram is invoked. Note that the formal parameter list of the matched subprogram must comply with the actual

- parameter list specified for the invoked subprogram, otherwise an error occurs upon invocation of the subprogram.
- If no match is found after searching up to the standalone program, then an error is thrown upon invocation of the subprogram.

Note: The Advanced Server search algorithm for subprogram invocation is not quite compatible with Oracle databases. For Oracle, the search looks for the first match of the first qualifier (that is *qualifier_1*). When such a match is found, all remaining qualifiers, the subprogram name, subprogram type, and arguments of the invocation must match the hierarchy content where the matching first qualifier is found, otherwise an error is thrown. For Advanced Server, a match is not found unless all qualifiers, the subprogram name, and the subprogram type of the invocation match the hierarchy content. If such an exact match is not initially found, Advanced Server continues the search progressing up the hierarchy.

The location of subprograms relative to the block from where the invocation is made can be accessed as follows:

- Subprograms declared in the local block can be invoked from the executable section or the exception section of the same block.
- Subprograms declared in the parent or other ancestor blocks can be invoked from the child block of the parent or other ancestors.
- Subprograms declared in sibling blocks can be called from a sibling block or from any descendent block of the sibling.

However, the following location of subprograms cannot be accessed relative to the block from where the invocation is made:

- Subprograms declared in blocks that are descendants of the block from where the invocation is attempted.
- Subprograms declared in blocks that are descendants of a sibling block from where the invocation is attempted.

The following examples illustrate the various conditions previously described.

Invoking Locally Declared Subprograms

The following example contains a single hierarchy of blocks contained within standalone procedure `level_0`. Within the executable section of procedure `level_1a`, the means of invoking the local procedure `level_2a` are shown, both with and without qualifiers.

Also note that access to the descendant of local procedure `level_2a`, which is procedure `level_3a`, is not permitted, with or without qualifiers. These calls are commented out in the example.

```
CREATE OR REPLACE PROCEDURE level_0
```

```

IS
  PROCEDURE level_1a
  IS
    PROCEDURE level_2a
    IS
      PROCEDURE level_3a
      IS
        BEGIN
          DBMS_OUTPUT.PUT_LINE('..... BLOCK level_3a');
          DBMS_OUTPUT.PUT_LINE('..... END BLOCK level_3a');
        END level_3a;
      BEGIN
        DBMS_OUTPUT.PUT_LINE('..... BLOCK level_2a');
        DBMS_OUTPUT.PUT_LINE('..... END BLOCK level_2a');
      END level_2a;
      BEGIN
        DBMS_OUTPUT.PUT_LINE('.. BLOCK level_1a');
        level_2a;                                -- Local block called
        level_1a.level_2a;                         -- Qualified local block called
        level_0.level_1a.level_2a;                  -- Double qualified local block called
--      level_3a;                                -- Error - Descendant of local block
--      level_2a.level_3a;                         -- Error - Descendant of local block
        DBMS_OUTPUT.PUT_LINE('.. END BLOCK level_1a');
      END level_1a;
    BEGIN
      DBMS_OUTPUT.PUT_LINE('BLOCK level_0');
      level_1a;
      DBMS_OUTPUT.PUT_LINE('END BLOCK level_0');
    END level_0;
  
```

When the standalone procedure is invoked, the output is the following, which indicates that procedure `level_2a` is successfully invoked from the calls in the executable section of procedure `level_1a`.

```

BEGIN
  level_0;
END;

BLOCK level_0
.. BLOCK level_1a
..... BLOCK level_2a
..... END BLOCK level_2a
..... BLOCK level_2a
..... END BLOCK level_2a
..... BLOCK level_2a
..... END BLOCK level_2a
.. END BLOCK level_1a
END BLOCK level_0

```

If you were to attempt to run procedure `level_0` with any of the calls to the descendent block uncommented, then an error occurs.

Invoking Subprograms Declared in Ancestor Blocks

The following example shows how subprograms can be invoked that are declared in parent and other ancestor blocks relative to the block where the invocation is made.

In this example, the executable section of procedure `level_3a` invokes procedure `level_2a`, which is its parent block. (Note that `v_cnt` is used to avoid an infinite loop.)

```

CREATE OR REPLACE PROCEDURE level_0
IS

```

```

v_cnt          NUMBER(2) := 0;
PROCEDURE level_1a
IS
    PROCEDURE level_2a
    IS
        PROCEDURE level_3a
        IS
        BEGIN
            DBMS_OUTPUT.PUT_LINE('..... BLOCK level_3a');
            v_cnt := v_cnt + 1;
            IF v_cnt < 2 THEN
                level_2a;                      -- Parent block called
            END IF;
            DBMS_OUTPUT.PUT_LINE('..... END BLOCK level_3a');
        END level_3a;
    BEGIN
        DBMS_OUTPUT.PUT_LINE('..... BLOCK level_2a');
        level_3a;                         -- Local block called
        DBMS_OUTPUT.PUT_LINE('..... END BLOCK level_2a');
    END level_2a;
    BEGIN
        DBMS_OUTPUT.PUT_LINE('.. BLOCK level_1a');
        level_2a;                         -- Local block called
        DBMS_OUTPUT.PUT_LINE('.. END BLOCK level_1a');
    END level_1a;
BEGIN
    DBMS_OUTPUT.PUT_LINE('BLOCK level_0');
    level_1a;
    DBMS_OUTPUT.PUT_LINE('END BLOCK level_0');
END level_0;

```

The following is the resulting output:

```

BEGIN
    level_0;
END;

BLOCK level_0
.. BLOCK level_1a
..... BLOCK level_2a
..... BLOCK level_3a
..... BLOCK level_2a
..... BLOCK level_3a
..... END BLOCK level_3a
..... END BLOCK level_2a
..... END BLOCK level_3a
..... END BLOCK level_2a
.. END BLOCK level_1a
END BLOCK level_0

```

In a similar example, the executable section of procedure `level_3a` invokes procedure `level_1a`, which is further up the ancestor hierarchy. (Note that `v_cnt` is used to avoid an infinite loop.)

```

CREATE OR REPLACE PROCEDURE level_0
IS
    v_cnt          NUMBER(2) := 0;
    PROCEDURE level_1a
    IS
        PROCEDURE level_2a
        IS
            PROCEDURE level_3a
            IS
            BEGIN
                DBMS_OUTPUT.PUT_LINE('..... BLOCK level_3a');
                v_cnt := v_cnt + 1;
                IF v_cnt < 2 THEN

```

```

        level_1a;                      -- Ancestor block called
    END IF;
    DBMS_OUTPUT.PUT_LINE('..... END BLOCK level_3a');
END level_3a;

BEGIN
    DBMS_OUTPUT.PUT_LINE('..... BLOCK level_2a');
    level_3a;                      -- Local block called
    DBMS_OUTPUT.PUT_LINE('..... END BLOCK level_2a');
END level_2a;

BEGIN
    DBMS_OUTPUT.PUT_LINE('.. BLOCK level_1a');
    level_2a;                      -- Local block called
    DBMS_OUTPUT.PUT_LINE('.. END BLOCK level_1a');
END level_1a;

BEGIN
    DBMS_OUTPUT.PUT_LINE('BLOCK level_0');
    level_1a;
    DBMS_OUTPUT.PUT_LINE('END BLOCK level_0');
END level_0;

```

The following is the resulting output:

```

BEGIN
    level_0;
END;

BLOCK level_0
.. BLOCK level_1a
..... BLOCK level_2a
..... BLOCK level_3a
.. BLOCK level_1a
..... BLOCK level_2a
..... BLOCK level_3a
..... END BLOCK level_3a
..... END BLOCK level_2a
.. END BLOCK level_1a
..... END BLOCK level_3a
..... END BLOCK level_2a
.. END BLOCK level_1a
END BLOCK level_0

```

Invoking Subprograms Declared in Sibling Blocks

The following examples show how subprograms can be invoked that are declared in a sibling block relative to the local, parent, or other ancestor blocks from where the invocation of the subprogram is made.

In this example, the executable section of procedure `level_1b` invokes procedure `level_1a`, which is its sibling block. Both are local to standalone procedure `level_0`.

Note that invocation of `level_2a` or equivalently, `level_1a.level_2a` from within procedure `level_1b` is commented out as this call would result in an error. Invoking a descendent subprogram (`level_2a`) of sibling block (`level_1a`) is not permitted.

```

CREATE OR REPLACE PROCEDURE level_0
IS
    v_cnt      NUMBER(2) := 0;
    PROCEDURE level_1a
    IS
        PROCEDURE level_2a
        IS
        BEGIN

```

```

        DBMS_OUTPUT.PUT_LINE('..... BLOCK level_2a');
        DBMS_OUTPUT.PUT_LINE('..... END BLOCK level_2a');
    END level_2a;
BEGIN
    DBMS_OUTPUT.PUT_LINE('.. BLOCK level_1a');
    DBMS_OUTPUT.PUT_LINE('.. END BLOCK level_1a');
END level_1a;
PROCEDURE level_1b
IS
BEGIN
    DBMS_OUTPUT.PUT_LINE('.. BLOCK level_1b');
    level_1a;                                -- Sibling block called
--    level_2a;                                -- Error - Descendant of sibling block
--    level_1a.level_2a;                         -- Error - Descendant of sibling block
    DBMS_OUTPUT.PUT_LINE('.. END BLOCK level_1b');
END level_1b;
BEGIN
    DBMS_OUTPUT.PUT_LINE('BLOCK level_0');
    level_1b;
    DBMS_OUTPUT.PUT_LINE('END BLOCK level_0');
END level_0;

```

The following is the resulting output:

```

BEGIN
    level_0;
END;

BLOCK level_0
.. BLOCK level_1b
.. BLOCK level_1a
.. END BLOCK level_1a
.. END BLOCK level_1b
END BLOCK level_0

```

In the following example, procedure `level_1a`, which is the sibling of procedure `level_1b`, which is an ancestor of procedure `level_3b` is successfully invoked.

```

CREATE OR REPLACE PROCEDURE level_0
IS
    PROCEDURE level_1a
    IS
    BEGIN
        DBMS_OUTPUT.PUT_LINE('.. BLOCK level_1a');
        DBMS_OUTPUT.PUT_LINE('.. END BLOCK level_1a');
    END level_1a;
    PROCEDURE level_1b
    IS
        PROCEDURE level_2b
        IS
            PROCEDURE level_3b
            IS
            BEGIN
                DBMS_OUTPUT.PUT_LINE('..... BLOCK level_3b');
                level_1a;                                -- Ancestor's sibling block called
                level_0.level_1a;                         -- Qualified ancestor's sibling block
                DBMS_OUTPUT.PUT_LINE('..... END BLOCK level_3b');
            END level_3b;
        BEGIN
            DBMS_OUTPUT.PUT_LINE('..... BLOCK level_2b');
            level_3b;                                -- Local block called
            DBMS_OUTPUT.PUT_LINE('..... END BLOCK level_2b');
        END level_2b;
    BEGIN
        DBMS_OUTPUT.PUT_LINE('.. BLOCK level_1b');
        level_2b;                                -- Local block called
        DBMS_OUTPUT.PUT_LINE('.. END BLOCK level_1b');
    END level_0;

```

```

    END level_1b;
BEGIN
  DBMS_OUTPUT.PUT_LINE('BLOCK level_0');
  level_1b;
  DBMS_OUTPUT.PUT_LINE('END BLOCK level_0');
END level_0;

```

The following is the resulting output:

```

BEGIN
  level_0;
END;

BLOCK level_0
.. BLOCK level_1b
..... BLOCK level_2b
..... BLOCK level_3b
.. BLOCK level_1a
.. END BLOCK level_1a
.. BLOCK level_1a
.. END BLOCK level_1a
..... END BLOCK level_3b
..... END BLOCK level_2b
.. END BLOCK level_1b
END BLOCK level_0

```

3.2.6.5 Using Forward Declarations

As discussed so far, when a subprogram is to be invoked, it must have been declared somewhere in the hierarchy of blocks within the standalone program, but prior to where it is invoked. In other words, when scanning the SPL code from beginning to end, the subprogram declaration must be found before its invocation.

However, there is a method of constructing the SPL code so that the full declaration of the subprogram (that is, its optional declaration section, its mandatory executable section, and optional exception section) appears in the SPL code after the point in the code where it is invoked.

This is accomplished by inserting a *forward declaration* in the SPL code prior to its invocation. The forward declaration is the specification of a subprocedure or subfunction name, formal parameters, and return type if it is a subfunction.

The full subprogram specification consisting of the optional declaration section, the executable section, and the optional exception section must be specified in the same declaration section as the forward declaration, but may appear following other subprogram declarations that invoke this subprogram with the forward declaration.

Typical usage of a forward declaration is when two subprograms invoke each other as shown by the following:

```

DECLARE
  FUNCTION add_one (
    p_add      IN NUMBER
  ) RETURN NUMBER;
  FUNCTION test_max (

```

```

    p_test      IN NUMBER)
RETURN NUMBER
IS
BEGIN
    IF p_test < 5 THEN
        RETURN add_one(p_test);
    END IF;
    DBMS_OUTPUT.PUT('Final value is ');
    RETURN p_test;
END;
FUNCTION add_one (
    p_add      IN NUMBER)
RETURN NUMBER
IS
BEGIN
    DBMS_OUTPUT.PUT_LINE('Increase by 1');
    RETURN test_max(p_add + 1);
END;
BEGIN
    DBMS_OUTPUT.PUT_LINE(test_max(3));
END;

```

Subfunction `test_max` invokes subfunction `add_one`, which also invokes subfunction `test_max`, so a forward declaration is required for one of the subprograms, which is implemented for `add_one` at the beginning of the anonymous block declaration section.

The resulting output from the anonymous block is as follows:

```

Increase by 1
Increase by 1
Final value is 5

```

3.2.6.6 Overloading Subprograms

Generally, subprograms of the same type (subprocedure or subfunction) with the same name, and same formal parameter specification can appear multiple times within the same standalone programs as long as they are not sibling blocks (that is, the subprograms are not declared in the same local block).

Each subprogram can be individually invoked depending upon the use of qualifiers and the location where the subprogram invocation is made as discussed in the previous sections.

It is however possible to declare subprograms, even as siblings, that are of the same subprogram type and name as long as certain aspects of the formal parameters differ. These characteristics (subprogram type, name, and formal parameter specification) is generally known as a program's *signature*.

The declaration of multiple subprograms where the signatures are identical except for certain aspects of the formal parameter specification is referred to as subprogram *overloading*.

Thus, the determination of which particular overloaded subprogram is to be invoked is determined by a match of the actual parameters specified by the subprogram invocation and the formal parameter lists of the overloaded subprograms.

Any of the following differences permit overloaded subprograms:

- The number of formal parameters are different.
- At least one pair of data types of the corresponding formal parameters (that is, compared according to the same order of appearance in the formal parameter list) are different, but are not aliases. Data type aliases are discussed later in this section.

Note that the following differences alone do not permit overloaded subprograms:

- Different formal parameter names
- Different parameter modes (`IN`, `IN OUT`, `OUT`) for the corresponding formal parameters
- For subfunctions, different data types in the `RETURN` clause

As previously indicated, one of the differences allowing overloaded subprograms are different data types.

However, certain data types have alternative names referred to as *aliases*, which can be used for the table definition.

For example, there are fixed length character data types that can be specified as `CHAR` or `CHARACTER`. There are variable length character data types that can be specified as `CHAR VARYING`, `CHARACTER VARYING`, `VARCHAR`, or `VARCHAR2`. For integers, there are `BINARY_INTEGER`, `PLS_INTEGER`, and `INTEGER` data types. For numbers, there are `NUMBER`, `NUMERIC`, `DEC`, and `DECIMAL` data types.

For detailed information about the data types supported by Advanced Server, please see the Database Compatibility for Oracle Developers Reference Guide, available from EnterpriseDB at:

<http://www.enterprisedb.com/products-services-training/products/documentation>

Thus, when attempting to create overloaded subprograms, the formal parameter data types are not considered different if the specified data types are aliases of each other.

It can be determined if certain data types are aliases of other types by displaying the table definition containing the data types in question.

For example, the following table definition contains some data types and their aliases.

```
CREATE TABLE data_type_aliases (
```

```

dt_BLOB           BLOB,
dt_LONG_RAW      LONG RAW,
dt_RAW            RAW(4),
dt_BYTEA          BYTEA,
dt_INTEGER        INTEGER,
dt_BINARY_INTEGER BINARY_INTEGER,
dt_PLS_INTEGER   PLS_INTEGER,
dt_REAL           REAL,
dt_DOUBLE_PRECISION DOUBLE PRECISION,
dt_FLOAT          FLOAT,
dt_NUMBER         NUMBER,
dt_DECIMAL        DECIMAL,
dt_NUMERIC        NUMERIC,
dt_CHAR           CHAR,
dt_CHARACTER      CHARACTER,
dt_VARCHAR2       VARCHAR2(4),
dt_CHAR_VARYING  CHAR VARYING(4),
dt_VARCHAR        VARCHAR(4)
);

```

Using the PSQL \d command to display the table definition, the Type column displays the data type internally assigned to each column based upon its data type in the table definition:

\d data_type_aliases	Column	Type	Modifiers
dt_blob	dt_blob	bytea	
dt_long_raw	dt_long_raw	bytea	
dt_raw	dt_raw	bytea(4)	
dt_bytea	dt_bytea	bytea	
dt_integer	dt_integer	integer	
dt_binary_integer	dt_binary_integer	integer	
dt_pls_integer	dt_pls_integer	integer	
dt_real	dt_real	real	
dt_double_precision	dt_double_precision	double precision	
dt_float	dt_float	double precision	
dt_number	dt_number	numeric	
dt_decimal	dt_decimal	numeric	
dt_numeric	dt_numeric	numeric	
dt_char	dt_char	character(1)	
dt_character	dt_character	character(1)	
dt_varchar2	dt_varchar2	character varying(4)	
dt_char_varying	dt_char_varying	character varying(4)	
dt_varchar	dt_varchar	character varying(4)	

In the example, the base set of data types are bytea, integer, real, double precision, numeric, character, and character varying.

When attempting to declare overloaded subprograms, a pair of formal parameter data types that are aliases would not be sufficient to allow subprogram overloading. Thus, parameters with data types INTEGER and PLS_INTEGER cannot overload a pair of subprograms, but data types INTEGER and REAL, or INTEGER and FLOAT, or INTEGER and NUMBER can overload the subprograms.

Note: The overloading rules based upon formal parameter data types are not compatible with Oracle databases. Generally, the Advanced Server rules are more flexible, and

certain combinations are allowed in Advanced Server that would result in an error when attempting to create the procedure or function in Oracle databases.

For certain pairs of data types used for overloading, casting of the arguments specified by the subprogram invocation may be required to avoid an error encountered during runtime of the subprogram. Invocation of a subprogram must include the actual parameter list that can specifically identify the data types. Certain pairs of overloaded data types may require the `CAST` function to explicitly identify data types. For example, pairs of overloaded data types that may require casting during the invocation are `CHAR` and `VARCHAR2`, or `NUMBER` and `REAL`.

The following example shows a group of overloaded subfunctions invoked from within an anonymous block. The executable section of the anonymous block contains the use of the `CAST` function to invoke overloaded functions with certain data types.

```

DECLARE
    FUNCTION add_it (
        p_add_1      IN BINARY_INTEGER,
        p_add_2      IN BINARY_INTEGER
    ) RETURN VARCHAR2
    IS
    BEGIN
        RETURN 'add_it BINARY_INTEGER: ' || TO_CHAR(p_add_1 + p_add_2,9999.9999);
    END add_it;
    FUNCTION add_it (
        p_add_1      IN NUMBER,
        p_add_2      IN NUMBER
    ) RETURN VARCHAR2
    IS
    BEGIN
        RETURN 'add_it NUMBER: ' || TO_CHAR(p_add_1 + p_add_2,999.9999);
    END add_it;
    FUNCTION add_it (
        p_add_1      IN REAL,
        p_add_2      IN REAL
    ) RETURN VARCHAR2
    IS
    BEGIN
        RETURN 'add_it REAL: ' || TO_CHAR(p_add_1 + p_add_2,9999.9999);
    END add_it;
    FUNCTION add_it (
        p_add_1      IN DOUBLE PRECISION,
        p_add_2      IN DOUBLE PRECISION
    ) RETURN VARCHAR2
    IS
    BEGIN
        RETURN 'add_it DOUBLE PRECISION: ' || TO_CHAR(p_add_1 + p_add_2,9999.9999);
    END add_it;
BEGIN
    DBMS_OUTPUT.PUT_LINE(add_it (25, 50));
    DBMS_OUTPUT.PUT_LINE(add_it (25.3333, 50.3333));
    DBMS_OUTPUT.PUT_LINE(add_it (TO_NUMBER(25.3333), TO_NUMBER(50.3333)));
    DBMS_OUTPUT.PUT_LINE(add_it (CAST('25.3333' AS REAL), CAST('50.3333' AS REAL)));
    DBMS_OUTPUT.PUT_LINE(add_it (CAST('25.3333' AS DOUBLE PRECISION),
                                CAST('50.3333' AS DOUBLE PRECISION)));
END;

```

The following is the output displayed from the anonymous block:

```

add_it BINARY_INTEGER:    75.0000
add_it NUMBER:    75.6666

```

```
add_it NUMBER:    75.6666
add_it REAL:      75.6666
add_it DOUBLE PRECISION: 75.6666
```

3.2.6.7 Accessing Subprogram Variables

Variable declared in blocks such as subprograms or anonymous blocks can be accessed from the executable section or the exception section of other blocks depending upon their relative location.

Accessing a variable means being able to reference it within a SQL statement or an SPL statement as is done with any local variable.

Note: If the subprogram signature contains formal parameters, these may be accessed in the same manner as local variables of the subprogram. In this section, all discussion related to variables of a subprogram also applies to formal parameters of the subprogram.

Access of variables not only includes those defined as a data type, but also includes others such as record types, collection types, and cursors.

The variable may be accessed by at most one qualifier, which is the name of the subprogram or labeled anonymous block in which the variable has been locally declared.

The syntax to reference a variable is shown by the following:

```
[qualifier.]variable
```

If specified, *qualifier* is the subprogram or labeled anonymous block in which *variable* has been declared in its declaration section (that is, it is a local variable).

Note: In Advanced Server, there is only one circumstance where two qualifiers are permitted. This scenario is for accessing public variables of packages where the reference can be specified in the following format:

```
schema_name.package_name.public_variable_name
```

For more information about supported package syntax, please see the Database Compatibility for Oracle Developers Built-In Packages Guide.

The following summarizes how variables can be accessed:

- Variables can be accessed as long as the block in which the variable has been locally declared is within the ancestor hierarchical path starting from the block containing the reference to the variable. Such variables declared in ancestor blocks are referred to as *global variables*.
- If a reference to an unqualified variable is made, the first attempt is to locate a local variable of that name. If such a local variable does not exist, then the search

for the variable is made in the parent of the current block, and so forth, proceeding up the ancestor hierarchy. If such a variable is not found, then an error occurs upon invocation of the subprogram.

- If a reference to a qualified variable is made, the same search process is performed as described in the previous bullet point, but searching for the first match of the subprogram or labeled anonymous block that contains the local variable. The search proceeds up the ancestor hierarchy until a match is found. If such a match is not found, then an error occurs upon invocation of the subprogram.

The following location of variables cannot be accessed relative to the block from where the reference to the variable is made:

- Variables declared in a descendent block cannot be accessed,
- Variables declared in a sibling block, a sibling block of an ancestor block, or any descendants within the sibling block cannot be accessed.

Note: The Advanced Server process for accessing variables is not compatible with Oracle databases. For Oracle, any number of qualifiers can be specified and the search is based upon the first match of the first qualifier in a similar manner to the Oracle matching algorithm for invoking subprograms.

The following example displays how variables in various blocks are accessed, with and without qualifiers. The lines that are commented out illustrate attempts to access variables that would result in an error.

```

CREATE OR REPLACE PROCEDURE level_0
IS
    v_level_0      VARCHAR2(20) := 'Value from level_0';
    PROCEDURE level_1a
    IS
        v_level_1a  VARCHAR2(20) := 'Value from level_1a';
        PROCEDURE level_2a
        IS
            v_level_2a      VARCHAR2(20) := 'Value from level_2a';
            BEGIN
                DBMS_OUTPUT.PUT_LINE('..... BLOCK level_2a');
                DBMS_OUTPUT.PUT_LINE('..... v_level_2a: ' || v_level_2a);
                DBMS_OUTPUT.PUT_LINE('..... v_level_1a: ' || v_level_1a);
                DBMS_OUTPUT.PUT_LINE('..... level_1a.v_level_1a: ' ||
                                      level_1a.v_level_1a);
                DBMS_OUTPUT.PUT_LINE('..... v_level_0: ' || v_level_0);
                DBMS_OUTPUT.PUT_LINE('..... level_0.v_level_0: ' || level_0.v_level_0);
                DBMS_OUTPUT.PUT_LINE('..... END BLOCK level_2a');
            END level_2a;
            BEGIN
                DBMS_OUTPUT.PUT_LINE('.. BLOCK level_1a');
                level_2a;
--                DBMS_OUTPUT.PUT_LINE('.... v_level_2a: ' || v_level_2a);
--                Error - Descendent block ----^
--                DBMS_OUTPUT.PUT_LINE('.... level_2a.v_level_2a: ' || level_2a.v_level_2a);
--                Error - Descendent block -----^
                DBMS_OUTPUT.PUT_LINE('.. END BLOCK level_1a');
            END level_1a;
    PROCEDURE level_1b
    IS
        v_level_1b      VARCHAR2(20) := 'Value from level_1b';

```

```

BEGIN
    DBMS_OUTPUT.PUT_LINE('.. BLOCK level_1b');
    DBMS_OUTPUT.PUT_LINE('.... v_level_1b: ' || v_level_1b);
    DBMS_OUTPUT.PUT_LINE('.... v_level_0 : ' || v_level_0);
--     DBMS_OUTPUT.PUT_LINE('.... level_1a.v_level_1a: ' || level_1a.v_level_1a);
--     Error - Sibling block -----
--     DBMS_OUTPUT.PUT_LINE('.... level_2a.v_level_2a: ' || level_2a.v_level_2a);
--     Error - Sibling block descendant -----
    DBMS_OUTPUT.PUT_LINE('.. END BLOCK level_1b');
END level_1b;
BEGIN
    DBMS_OUTPUT.PUT_LINE('BLOCK level_0');
    DBMS_OUTPUT.PUT_LINE('.. v_level_0: ' || v_level_0);
    level_1a;
    level_1b;
    DBMS_OUTPUT.PUT_LINE('END BLOCK level_0');
END level_0;

```

The following is the output showing the content of each variable when the procedure is invoked:

```

BEGIN
    level_0;
END;

BLOCK level_0
.. v_level_0: Value from level_0
.. BLOCK level_1a
..... BLOCK level_2a
..... v_level_2a: Value from level_2a
..... v_level_1a: Value from level_1a
..... level_1a.v_level_1a: Value from level_1a
..... v_level_0: Value from level_0
..... level_0.v_level_0: Value from level_0
..... END BLOCK level_2a
.. END BLOCK level_1a
.. BLOCK level_1b
.... v_level_1b: Value from level_1b
.... v_level_0 : Value from level_0
.. END BLOCK level_1b
END BLOCK level_0

```

The following example shows similar access attempts when all variables in all blocks have the same name:

```

CREATE OR REPLACE PROCEDURE level_0
IS
    v_common      VARCHAR2(20) := 'Value from level_0';
    PROCEDURE level_1a
    IS
        v_common      VARCHAR2(20) := 'Value from level_1a';
        PROCEDURE level_2a
        IS
            v_common      VARCHAR2(20) := 'Value from level_2a';
            BEGIN
                DBMS_OUTPUT.PUT_LINE('..... BLOCK level_2a');
                DBMS_OUTPUT.PUT_LINE('..... v_common: ' || v_common);
                DBMS_OUTPUT.PUT_LINE('..... level_2a.v_common: ' || level_2a.v_common);
                DBMS_OUTPUT.PUT_LINE('..... level_1a.v_common: ' || level_1a.v_common);
                DBMS_OUTPUT.PUT_LINE('..... level_0.v_common: ' || level_0.v_common);
                DBMS_OUTPUT.PUT_LINE('..... END BLOCK level_2a');
            END level_2a;
            BEGIN
                DBMS_OUTPUT.PUT_LINE('.. BLOCK level_1a');
                DBMS_OUTPUT.PUT_LINE('.... v_common: ' || v_common);
                DBMS_OUTPUT.PUT_LINE('.... level_0.v_common: ' || level_0.v_common);
                level_2a;
            END;
        END;
    END;

```

```

        DBMS_OUTPUT.PUT_LINE('.. END BLOCK level_1a');
END level_1a;
PROCEDURE level_1b
IS
    v_common      VARCHAR2(20) := 'Value from level_1b';
BEGIN
    DBMS_OUTPUT.PUT_LINE('.. BLOCK level_1b');
    DBMS_OUTPUT.PUT_LINE('.... v_common: ' || v_common);
    DBMS_OUTPUT.PUT_LINE('.... level_0.v_common : ' || level_0.v_common);
    DBMS_OUTPUT.PUT_LINE('.. END BLOCK level_1b');
END level_1b;
BEGIN
    DBMS_OUTPUT.PUT_LINE('BLOCK level_0');
    DBMS_OUTPUT.PUT_LINE('.. v_common: ' || v_common);
    level_1a;
    level_1b;
    DBMS_OUTPUT.PUT_LINE('END BLOCK level_0');
END level_0;

```

The following is the output showing the content of each variable when the procedure is invoked:

```

BEGIN
    level_0;
END;

BLOCK level_0
.. v_common: Value from level_0
.. BLOCK level_1a
.... v_common: Value from level_1a
.... level_0.v_common: Value from level_0
..... BLOCK level_2a
..... v_common: Value from level_2a
..... level_2a.v_common: Value from level_2a
..... level_1a.v_common: Value from level_1a
..... level_0.v_common: Value from level_0
..... END BLOCK level_2a
.. END BLOCK level_1a
.. BLOCK level_1b
.... v_common: Value from level_1b
.... level_0.v_common : Value from level_0
.. END BLOCK level_1b
END BLOCK level_0

```

As previously discussed, the labels on anonymous blocks can also be used to qualify access to variables. The following example shows variable access within a set of nested anonymous blocks:

```

DECLARE
    v_common      VARCHAR2(20) := 'Value from level_0';
BEGIN
    DBMS_OUTPUT.PUT_LINE('BLOCK level_0');
    DBMS_OUTPUT.PUT_LINE('.. v_common: ' || v_common);
    <<level_1a>>
    DECLARE
        v_common      VARCHAR2(20) := 'Value from level_1a';
    BEGIN
        DBMS_OUTPUT.PUT_LINE('.. BLOCK level_1a');
        DBMS_OUTPUT.PUT_LINE('.... v_common: ' || v_common);
        <<level_2a>>
        DECLARE
            v_common      VARCHAR2(20) := 'Value from level_2a';
        BEGIN
            DBMS_OUTPUT.PUT_LINE('..... BLOCK level_2a');
            DBMS_OUTPUT.PUT_LINE('..... v_common: ' || v_common);
            DBMS_OUTPUT.PUT_LINE('..... level_1a.v_common: ' || level_1a.v_common);
        END;
    END;

```

```

        DBMS_OUTPUT.PUT_LINE('..... END BLOCK level_2a');
    END;
    DBMS_OUTPUT.PUT_LINE('.. END BLOCK level_1a');
END;
<<level_1b>>
DECLARE
    v_common      VARCHAR2(20) := 'Value from level_1b';
BEGIN
    DBMS_OUTPUT.PUT_LINE('.. BLOCK level_1b');
    DBMS_OUTPUT.PUT_LINE('.... v_common: ' || v_common);
    DBMS_OUTPUT.PUT_LINE('.... level_1b.v_common: ' || level_1b.v_common);
    DBMS_OUTPUT.PUT_LINE('.. END BLOCK level_1b');
END;
DBMS_OUTPUT.PUT_LINE('END BLOCK level_0');
END;

```

The following is the output showing the content of each variable when the anonymous block is invoked:

```

BLOCK level_0
.. v_common: Value from level_0
.. BLOCK level_1a
.... v_common: Value from level_1a
..... BLOCK level_2a
..... v_common: Value from level_2a
..... level_1a.v_common: Value from level_1a
..... END BLOCK level_2a
.. END BLOCK level_1a
.. BLOCK level_1b
.... v_common: Value from level_1b
.... level_1b.v_common: Value from level_1b
.. END BLOCK level_1b
END BLOCK level_0

```

The following example is an object type whose object type method, `display_emp`, contains record type `emp_typ` and subprocedure `emp_sal_query`. Record variable `r_emp` declared locally to `emp_sal_query` is able to access the record type `emp_typ` declared in the parent block `display_emp`.

```

CREATE OR REPLACE TYPE emp_pay_obj_typ AS OBJECT
(
    empno          NUMBER(4),
    MEMBER PROCEDURE display_emp(SELF IN OUT emp pay obj typ)
);

CREATE OR REPLACE TYPE BODY emp_pay_obj_typ AS
    MEMBER PROCEDURE display_emp (SELF IN OUT emp_pay_obj_typ)
    IS
        TYPE emp_typ IS RECORD (
            ename          emp.ename%TYPE,
            job            emp.job%TYPE,
            hiredate       emp.hiredate%TYPE,
            sal             emp.sal%TYPE,
            deptno         emp.deptno%TYPE
        );
        PROCEDURE emp_sal_query (
            p_empno        IN emp.empno%TYPE
        )
        IS
            r_emp          emp_typ;
            v_avgsal      emp.sal%TYPE;
        BEGIN
            SELECT ename, job, hiredate, sal, deptno
                INTO r_emp.ename, r_emp.job, r_emp.hiredate, r_emp.sal, r_emp.deptno
                FROM emp WHERE empno = p_empno;

```

```

DBMS_OUTPUT.PUT_LINE('Employee # : ' || p.empno);
DBMS_OUTPUT.PUT_LINE('Name      : ' || r.emp.ename);
DBMS_OUTPUT.PUT_LINE('Job       : ' || r.emp.job);
DBMS_OUTPUT.PUT_LINE('Hire Date : ' || r.emp.hiredate);
DBMS_OUTPUT.PUT_LINE('Salary    : ' || r.emp.sal);
DBMS_OUTPUT.PUT_LINE('Dept #   : ' || r.emp.deptno);

SELECT AVG(sal) INTO v_avgsal
FROM emp WHERE deptno = r.emp.deptno;
IF r.emp.sal > v_avgsal THEN
    DBMS_OUTPUT.PUT_LINE('Employee''s salary is more than the '
    || 'department average of ' || v_avgsal);
ELSE
    DBMS_OUTPUT.PUT_LINE('Employee''s salary does not exceed the '
    || 'department average of ' || v_avgsal);
END IF;
END;
BEGIN
    emp_sal_query(SELF.empno);
END;
END;

```

The following is the output displayed when an instance of the object type is created and procedure `display_emp` is invoked:

```

DECLARE
    v_emp          EMP_PAY_OBJ_TYP;
BEGIN
    v_emp := emp_pay_obj_typ(7900);
    v_emp.display_emp;
END;

Employee # : 7900
Name      : JAMES
Job       : CLERK
Hire Date : 03-DEC-81 00:00:00
Salary    : 950.00
Dept #   : 30
Employee's salary does not exceed the department average of 1566.67

```

The following example is a package with three levels of subprocedures. A record type, collection type, and cursor type declared in the upper level procedure can be accessed by the descendent subprocedure.

```

CREATE OR REPLACE PACKAGE emp_dept_pkg
IS
    PROCEDURE display_emp (
        p_deptno      NUMBER
    );
END;

CREATE OR REPLACE PACKAGE BODY emp_dept_pkg
IS
    PROCEDURE display_emp (
        p_deptno      NUMBER
    )
    IS
        TYPE emp_rec_typ IS RECORD (
            empno          emp.empno%TYPE,
            ename          emp.ename%TYPE
        );
        TYPE emp_arr_typ IS TABLE OF emp_rec_typ INDEX BY BINARY_INTEGER;
        TYPE emp_cur_type IS REF CURSOR RETURN emp_rec_typ;
        PROCEDURE emp_by_dept (
            p_deptno      emp.deptno%TYPE
        )
    END;

```

```

IS
    emp_arr          emp_arr_typ;
    emp_refcur      emp_cur_type;
    i                BINARY_INTEGER := 0;
PROCEDURE display_emp_arr
IS
BEGIN
    DBMS_OUTPUT.PUT_LINE('EMPNO      ENAME');
    DBMS_OUTPUT.PUT_LINE('-----  -----');
    FOR j IN emp_arr.FIRST .. emp_arr.LAST LOOP
        DBMS_OUTPUT.PUT_LINE(emp_arr(j).empno || '      ' ||
                             emp_arr(j).ename);
    END LOOP;
    END display_emp_arr;
BEGIN
    OPEN emp_refcur FOR SELECT empno, ename FROM emp WHERE deptno = p_deptno;
    LOOP
        i := i + 1;
        FETCH emp_refcur INTO emp_arr(i).empno, emp_arr(i).ename;
        EXIT WHEN emp_refcur%NOTFOUND;
    END LOOP;
    CLOSE emp_refcur;
    display_emp_arr;
END emp_by_dept;
BEGIN
    emp_by_dept(p_deptno);
END;
END;

```

The following is the output displayed when the top level package procedure is invoked:

```

BEGIN
    emp_dept_pkg.display_emp(20);
END;

EMPNO      ENAME
-----  -----
7369       SMITH
7566       JONES
7788       SCOTT
7876       ADAMS
7902       FORD

```

3.2.7 Compilation Errors in Procedures and Functions

When the Advanced Server parsers compile a procedure or function, they confirm that both the `CREATE` statement and the programbody (that portion of the program that follows the `AS` keyword) conforms to the grammar rules for SPL and SQL constructs. By default, the server will terminate the compilation process if a parser detects an error. Note that the parsers detect syntax errors in expressions, but not semantic errors (i.e. an expression referencing a non-existent column, table, or function, or a value of incorrect type).

`spl.max_error_count` instructs the server to stop parsing if it encounters the specified number of errors in SPL code, or when it encounters an error in SQL code. The default value of `spl.max_error_count` is 10; the maximum value is 1000. Setting `spl.max_error_count` to a value of 1 instructs the server to stop parsing when it encounters the first error in either SPL or SQL code.

You can use the `SET` command to specify a value for `spl.max_error_count` for your current session. The syntax is:

```
SET spl.max_error_count = number_of_errors
```

Where `number_of_errors` specifies the number of SPL errors that may occur before the server halts the compilation process. For example:

```
SET spl.max_error_count = 6
```

The example instructs the server to continue past the first five SPL errors it encounters. When the server encounters the sixth error it will stop validating, and print six detailed error messages, and one error summary.

To save time when developing new code, or when importing existing code from another source, you may want to set the `spl.max_error_count` configuration parameter to a relatively high number of errors.

Please note that if you instruct the server to continue parsing in spite of errors in the SPL code in a programbody, and the parser encounters an error in a segment of SQL code, there may still be errors in any SPL or SQL code that follows the erroneous SQL code. For example, the following function results in two errors:

```
CREATE FUNCTION computeBonus(baseSalary number) RETURN
number AS
BEGIN

    bonus := baseSalary * 1.10;
    total := bonus + 100;
```

```
    RETURN bonus;
END;

ERROR:  "bonus" is not a known variable
LINE 4:      bonus := baseSalary * 1.10;
           ^
ERROR:  "total" is not a known variable
LINE 5:      total := bonus + 100;
           ^
ERROR:  compilation of SPL function/procedure
"computeBonus" failed due to 2 errors
```

The following example adds a `SELECT` statement to the previous example. The error in the `SELECT` statement masks the other errors that follow:

```
CREATE FUNCTION computeBonus(employeeName number) RETURN
number AS
BEGIN
    SELECT salary INTO baseSalary FROM emp
    WHERE ename = employeeName;

    bonus := baseSalary * 1.10;
    total := bonus + 100;

    RETURN bonus;

END;

ERROR:  "basesalary" is not a known variable
LINE 3:      SELECT salary INTO baseSalary FROM emp WHERE
ename = emp...
```

3.2.8 Program Security

Security over what user may execute an SPL program and what database objects an SPL program may access for any given user executing the program is controlled by the following:

- Privilege to execute a program.
- Privileges granted on the database objects (including other SPL programs) which a program attempts to access.
- Whether the program is defined with definer's rights or invoker's rights.

These aspects are discussed in the following sections.

3.2.8.1 EXECUTE Privilege

An SPL program(function, procedure, or package) can begin execution only if any of the following are true:

- The current user is a superuser, or
- The current user has been granted `EXECUTE` privilege on the SPL program, or
- The current user inherits `EXECUTE` privilege on the SPL program by virtue of being a member of a group which does have such privilege, or
- `EXECUTE` privilege has been granted to the `PUBLIC` group.

Whenever an SPL program is created in Advanced Server, `EXECUTE` privilege is automatically granted to the `PUBLIC` group by default, therefore, any user can immediately execute the program.

This default privilege can be removed by using the `REVOKE EXECUTE` command. The following is an example:

```
REVOKE EXECUTE ON PROCEDURE list_emp FROM PUBLIC;
```

Explicit `EXECUTE` privilege on the program can then be granted to individual users or groups.

```
GRANT EXECUTE ON PROCEDURE list_emp TO john;
```

Now, user, `john`, can execute the `list_emp` program; other users who do not meet any of the conditions listed at the beginning of this section cannot.

Once a program begins execution, the next aspect of security is what privilege checks occur if the program attempts to perform an action on any database object including:

- Reading or modifying table or view data.
- Creating, modifying, or deleting a database object such as a table, view, index, or sequence.
- Obtaining the current or next value from a sequence.
- Calling another program(function, procedure, or package).

Each such action can be protected by privileges on the database object either allowed or disallowed for the user.

Note that it is possible for a database to have more than one object of the same type with the same name, but each such object belonging to a different schema in the database. If this is the case, which object is being referenced by an SPL program? This is the topic of the next section.

3.2.8.2 Database Object Name Resolution

A database object inside an SPL program may either be referenced by its qualified name or by an unqualified name. A qualified name is in the form of *schema.name* where *schema* is the name of the schema under which the database object with identifier, *name*, exists. An unqualified name does not have the “*schema.*” portion. When a reference is made to a qualified name, there is absolutely no ambiguity as to exactly which database object is intended – it either does or does not exist in the specified schema.

Locating an object with an unqualified name, however, requires the use of the current user’s search path. When a user becomes the current user of a session, a default search path is always associated with that user. The search path consists of a list of schemas which are searched in left-to-right order for locating an unqualified database object reference. The object is considered non-existent if it can’t be found in any of the schemas in the search path. The default search path can be displayed in PSQL using the `SHOW search_path` command.

```
SHOW search_path;
   search_path
-----
$user,public,sys,dbo
(1 row)
```

`$user` in the above search path is a generic placeholder that refers to the current user so if the current user of the above session is `enterprisedb`, an unqualified database object would be searched for in the following schemas in this order – first, `enterprisedb`, then `public`, then `sys`, and finally, `dbo`.

Once an unqualified name has been resolved in the search path, it can be determined if the current user has the appropriate privilege to perform the desired action on that specific object.

Note: The concept of the search path is not compatible with Oracle databases. For an unqualified reference, Oracle simply looks in the schema of the current user for the named database object. It also important to note that in Oracle, a user and his or her schema is the same entity while in Advanced Server, a user and a schema are two distinct objects.

3.2.8.3 Database Object Privileges

Once an SPL program begins execution, any attempt to access a database object from within the program results in a check to ensure the current user has the authorization to perform the intended action against the referenced object. Privileges on database objects are bestowed and removed using the `GRANT` and `REVOKE` commands, respectively. If the current user attempts unauthorized access on a database object, then the program will throw an exception. See Section [3.5.7](#) for information about exception handling.

The final topic discusses exactly who is the current user.

3.2.8.4 Definer's vs. Invokers Rights

When an SPL program is about to begin execution, a determination is made as to what user is to be associated with this process. This user is referred to as the *current user*. The current user's database object privileges are used to determine whether or not access to database objects referenced in the program will be permitted. The current, prevailing search path in effect when the program is invoked will be used to resolve any unqualified object references.

The selection of the current user is influenced by whether the SPL program was created with definer's right or invoker's rights. The `AUTHID` clause determines that selection. Appearance of the clause `AUTHID DEFINER` gives the program definer's rights. This is also the default if the `AUTHID` clause is omitted. Use of the clause `AUTHID CURRENT_USER` gives the program invoker's rights. The difference between the two is summarized as follows:

- If a program has *definer's rights*, then the owner of the program becomes the current user when program execution begins. The program owner's database object privileges are used to determine if access to a referenced object is permitted. In a definer's rights program, it is irrelevant as to which user actually invoked the program.
- If a program has *invoker's rights*, then the current user at the time the program is called remains the current user while the program is executing (but not necessarily within called subprograms – see the following bullet points). When an invoker's rights program is invoked, the current user is typically the user that started the

session (i.e., made the database connection) although it is possible to change the current user after the session has started using the SET ROLE command. In an invoker's rights program, it is irrelevant as to which user actually owns the program.

From the previous definitions, the following observations can be made:

- If a definer's rights program calls a definer's rights program, the current user changes from the owner of the calling program to the owner of the called program during execution of the called program.
- If a definer's rights program calls an invoker's rights program, the owner of the calling program remains the current user during execution of both the calling and called programs.
- If an invoker's rights program calls an invoker's rights program, the current user of the calling program remains the current user during execution of the called program.
- If an invoker's rights program calls a definer's rights program, the current user switches to the owner of the definer's rights program during execution of the called program.

The same principles apply if the called program in turn calls another program in the cases cited above.

This section on security concludes with an example using the sample application.

3.2.8.5 Security Example

In the following example, a new database will be created along with two users – `hr_mgr` who will own a copy of the entire sample application in schema, `hr_mgr`; and `sales_mgr` who will own a schema named, `sales_mgr`, that will have a copy of only the `emp` table containing only the employees who work in sales.

The procedure `list_emp`, function `hire_clerk`, and package `emp_admin` will be used in this example. All of the default privileges that are granted upon installation of the sample application will be removed and then be explicitly re-granted so as to present a more secure environment in this example.

Programs `list_emp` and `hire_clerk` will be changed from the default of definer's rights to invoker's rights. It will be then illustrated that when `sales_mgr` runs these programs, they act upon the `emp` table in `sales_mgr`'s schema since `sales_mgr`'s search path and privileges will be used for name resolution and authorization checking.

Programs `get_dept_name` and `hire_emp` in the `emp_admin` package will then be executed by `sales_mgr`. In this case, the `dept` table and `emp` table in `hr_mgr`'s schema will be accessed as `hr_mgr` is the owner of the `emp_admin` package which is using

definer's rights. Since the default search path is in effect with the \$user placeholder, the schema matching the user (in this case, hr_mgr) is used to find the tables.

Step 1 – Create Database and Users

As user enterpriseedb, create the hr database:

```
CREATE DATABASE hr;
```

Switch to the hr database and create the users:

```
\c hr enterpriseedb
CREATE USER hr_mgr IDENTIFIED BY password;
CREATE USER sales_mgr IDENTIFIED BY password;
```

Step 2 – Create the Sample Application

Create the entire sample application, owned by hr_mgr, in hr_mgr's schema.

```
\c - hr_mgr
\i /opt/edb/as10/installer/server/edb-sample.sql

BEGIN
CREATE TABLE
CREATE TABLE
CREATE TABLE
CREATE VIEW
CREATE SEQUENCE
.
.
.
CREATE PACKAGE
CREATE PACKAGE BODY
COMMIT
```

Step 3 – Create the emp Table in Schema sales_mgr

Create a subset of the emp table owned by sales_mgr in sales_mgr's schema.

```
\c - hr_mgr
GRANT USAGE ON SCHEMA hr_mgr TO sales_mgr;
\c - sales_mgr
CREATE TABLE emp AS SELECT * FROM hr_mgr.emp WHERE job = 'SALESMAN';
```

In the above example, the GRANT USAGE ON SCHEMA command is given to allow sales_mgr access into hr_mgr's schema to make a copy of hr_mgr's emp table. This step is required in Advanced Server and is not compatible with Oracle databases since Oracle does not have the concept of a schema that is distinct from its user.

Step 4 – Remove Default Privileges

Remove all privileges to later illustrate the minimum required privileges needed.

```
\c - hr_mgr
REVOKE USAGE ON SCHEMA hr_mgr FROM sales_mgr;
REVOKE ALL ON dept FROM PUBLIC;
REVOKE ALL ON emp FROM PUBLIC;
REVOKE ALL ON next_empno FROM PUBLIC;
REVOKE EXECUTE ON FUNCTION new_empno() FROM PUBLIC;
REVOKE EXECUTE ON PROCEDURE list_emp FROM PUBLIC;
REVOKE EXECUTE ON FUNCTION hire_clerk(VARCHAR2,NUMBER) FROM PUBLIC;
REVOKE EXECUTE ON PACKAGE emp_admin FROM PUBLIC;
```

Step 5 – Change list_emp to Invoker’s Rights

While connected as user, hr_mgr, add the AUTHID CURRENT_USER clause to the list_emp program and resave it in Advanced Server. When performing this step, be sure you are logged on as hr_mgr, otherwise the modified program may wind up in the public schema instead of in hr_mgr’s schema.

```
CREATE OR REPLACE PROCEDURE list_emp
AUTHID CURRENT_USER
IS
    v_empno      NUMBER(4);
    v_ename      VARCHAR2(10);
    CURSOR emp_cur IS
        SELECT empno, ename FROM emp ORDER BY empno;
BEGIN
    OPEN emp_cur;
    DBMS_OUTPUT.PUT_LINE('EMPNO      ENAME');
    DBMS_OUTPUT.PUT_LINE('-----  -----');
    LOOP
        FETCH emp_cur INTO v_empno, v_ename;
        EXIT WHEN emp_cur%NOTFOUND;
        DBMS_OUTPUT.PUT_LINE(v_empno || '      ' || v_ename);
    END LOOP;
    CLOSE emp_cur;
END;
```

Step 6 – Change hire_clerk to Invoker’s Rights and Qualify Call to new_empno

While connected as user, hr_mgr, add the AUTHID CURRENT_USER clause to the hire_clerk program.

Also, after the BEGIN statement, fully qualify the reference, new_empno, to hr_mgr.new_empno in order to ensure the hire_clerk function call to the new_empno function resolves to the hr_mgr schema.

When resaving the program, be sure you are logged on as hr_mgr, otherwise the modified program may wind up in the public schema instead of in hr_mgr’s schema.

```
CREATE OR REPLACE FUNCTION hire_clerk (
    p_ename      VARCHAR2,
    p_deptno     NUMBER
) RETURN NUMBER
```

```

AUTHID CURRENT_USER
IS
    v_empno      NUMBER(4);
    v_ename      VARCHAR2(10);
    v_job        VARCHAR2(9);
    v_mgr        NUMBER(4);
    v_hiredate   DATE;
    v_sal         NUMBER(7,2);
    v_comm        NUMBER(7,2);
    v_deptno     NUMBER(2);
BEGIN
    v_empno := hr_mgr.new_empno;
    INSERT INTO emp VALUES (v_empno, p_ename, 'CLERK', 7782,
                           TRUNC(SYSDATE), 950.00, NULL, p_deptno);
    SELECT empno, ename, job, mgr, hiredate, sal, comm, deptno INTO
        v_empno, v_ename, v_job, v_mgr, v_hiredate, v_sal, v_comm, v_deptno
        FROM emp WHERE empno = v_empno;
    DBMS_OUTPUT.PUT_LINE('Department : ' || v_deptno);
    DBMS_OUTPUT.PUT_LINE('Employee No: ' || v_empno);
    DBMS_OUTPUT.PUT_LINE('Name      : ' || v_ename);
    DBMS_OUTPUT.PUT_LINE('Job       : ' || v_job);
    DBMS_OUTPUT.PUT_LINE('Manager   : ' || v_mgr);
    DBMS_OUTPUT.PUT_LINE('Hire Date : ' || v_hiredate);
    DBMS_OUTPUT.PUT_LINE('Salary    : ' || v_sal);
    DBMS_OUTPUT.PUT_LINE('Commission : ' || v_comm);
    RETURN v_empno;
EXCEPTION
    WHEN OTHERS THEN
        DBMS_OUTPUT.PUT_LINE('The following is SQLERRM:');
        DBMS_OUTPUT.PUT_LINE(SQLERRM);
        DBMS_OUTPUT.PUT_LINE('The following is SQLCODE:');
        DBMS_OUTPUT.PUT_LINE(SQLCODE);
        RETURN -1;
END;

```

Step 7 – Grant Required Privileges

While connected as user, `hr_mgr`, grant the privileges needed so `sales_mgr` can execute the `list_emp` procedure, `hire_clerk` function, and `emp_admin` package. Note that the only data object `sales_mgr` has access to is the `emp` table in the `sales_mgr` schema. `sales_mgr` has no privileges on any table in the `hr_mgr` schema.

```

GRANT USAGE ON SCHEMA hr_mgr TO sales_mgr;
GRANT EXECUTE ON PROCEDURE list_emp TO sales_mgr;
GRANT EXECUTE ON FUNCTION hire_clerk(VARCHAR2,NUMBER) TO sales_mgr;
GRANT EXECUTE ON FUNCTION new_empno() TO sales_mgr;
GRANT EXECUTE ON PACKAGE emp_admin TO sales_mgr;

```

Step 8 – Run Programs `list_emp` and `hire_clerk`

Connect as user, `sales_mgr`, and run the following anonymous block:

```

\c - sales_mgr
DECLARE
    v_empno      NUMBER(4);
BEGIN
    hr_mgr.list_emp;
    DBMS_OUTPUT.PUT_LINE('*** Adding new employee ***');

```

```

v_empno := hr_mgr.hire_clerk('JONES',40);
DBMS_OUTPUT.PUT_LINE('*** After new employee added ***');
hr_mgr.list_emp;
END;

EMPNO      ENAME
----- -----
7499       ALLEN
7521       WARD
7654       MARTIN
7844       TURNER
*** Adding new employee ***
Department : 40
Employee No: 8000
Name       : JONES
Job        : CLERK
Manager    : 7782
Hire Date  : 08-NOV-07 00:00:00
Salary     : 950.00
*** After new employee added ***
EMPNO      ENAME
----- -----
7499       ALLEN
7521       WARD
7654       MARTIN
7844       TURNER
8000       JONES

```

The table and sequence accessed by the programs of the anonymous block are illustrated in the following diagram. The gray ovals represent the schemas of `sales_mgr` and `hr_mgr`. The current user during each program execution is shown within parenthesis in bold red font.

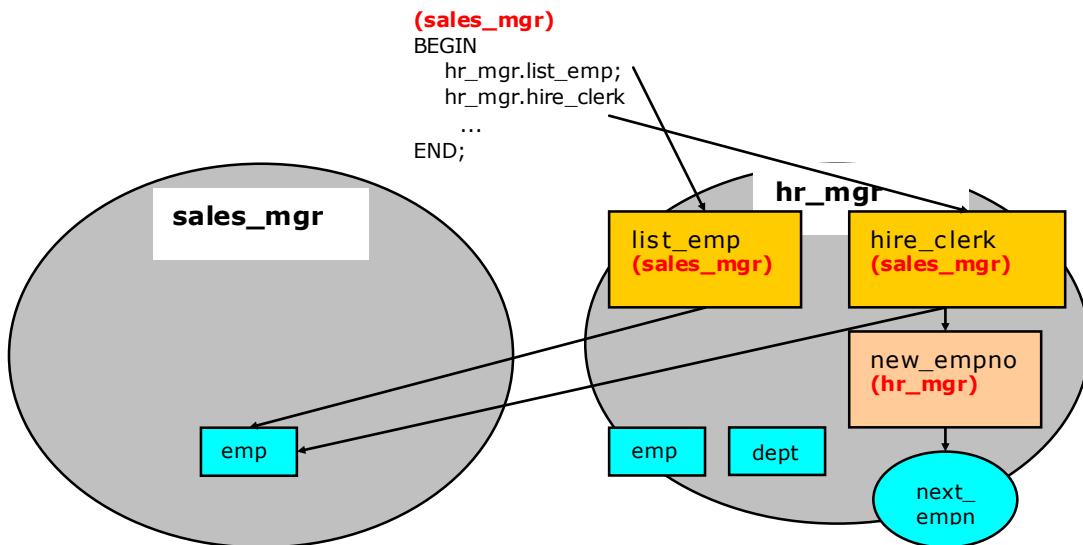


Figure 3 - Invoker's Rights Programs

Selecting from `sales_mgr`'s `emp` table shows that the update was made in this table.

```

SELECT empno, ename, hiredate, sal, deptno,
hr_mgr.emp_admin.get_dept_name(deptno) FROM sales_mgr.emp;

empno | ename |      hiredate      |    sal    | deptno | get_dept_name
-----+-----+-----+-----+-----+-----+
 7499 | ALLEN | 20-FEB-81 00:00:00 | 1600.00 |     30 | SALES
 7521 | WARD  | 22-FEB-81 00:00:00 | 1250.00 |     30 | SALES
 7654 | MARTIN | 28-SEP-81 00:00:00 | 1250.00 |     30 | SALES
 7844 | TURNER | 08-SEP-81 00:00:00 | 1500.00 |     30 | SALES
 8000 | JONES  | 08-NOV-07 00:00:00 |   950.00 |     40 | OPERATIONS
(5 rows)

```

The following diagram shows that the `SELECT` command references the `emp` table in the `sales_mgr` schema, but the `dept` table referenced by the `get_dept_name` function in the `emp_admin` package is from the `hr_mgr` schema since the `emp_admin` package has definer's rights and is owned by `hr_mgr`. The default search path setting with the `$user` placeholder resolves the access by user `hr_mgr` to the `dept` table in the `hr_mgr` schema.

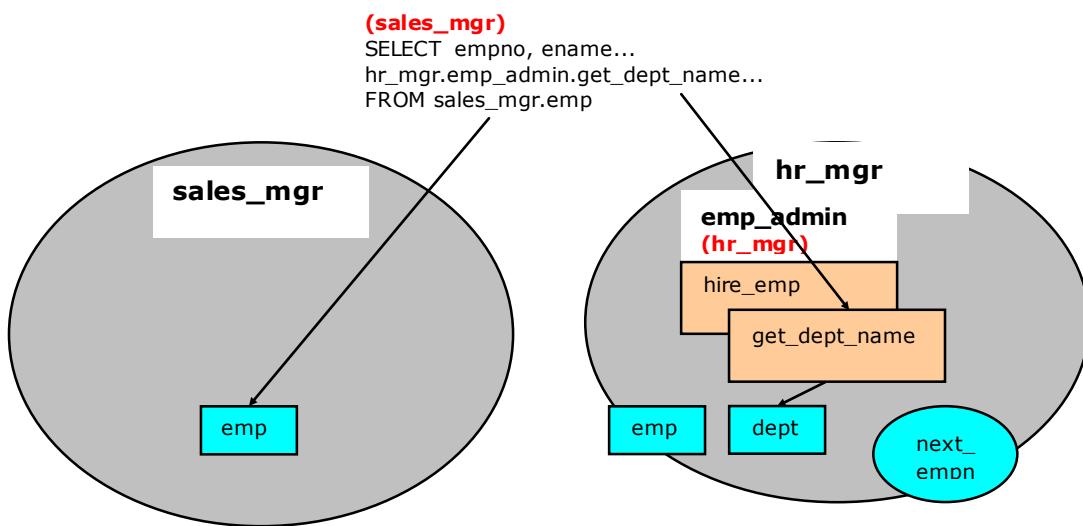


Figure 4 Definer's Rights Package

Step 9 – Run Program `hire_emp` in the `emp_admin` Package

While connected as user `sales_mgr`, run the `hire_emp` procedure in the `emp_admin` package.

```

EXEC hr_mgr.emp_admin.hire_emp(9001,
'ALICE','SALESMAN',8000,TRUNC(SYSDATE),1000,7369,40);

```

This diagram illustrates that the `hire_emp` procedure in the `emp_admin` definer's rights package updates the `emp` table belonging to `hr_mgr` since the object privileges of

`hr_mgr` are used, and the default search path setting with the `$user` placeholder resolves to the schema of `hr_mgr`.

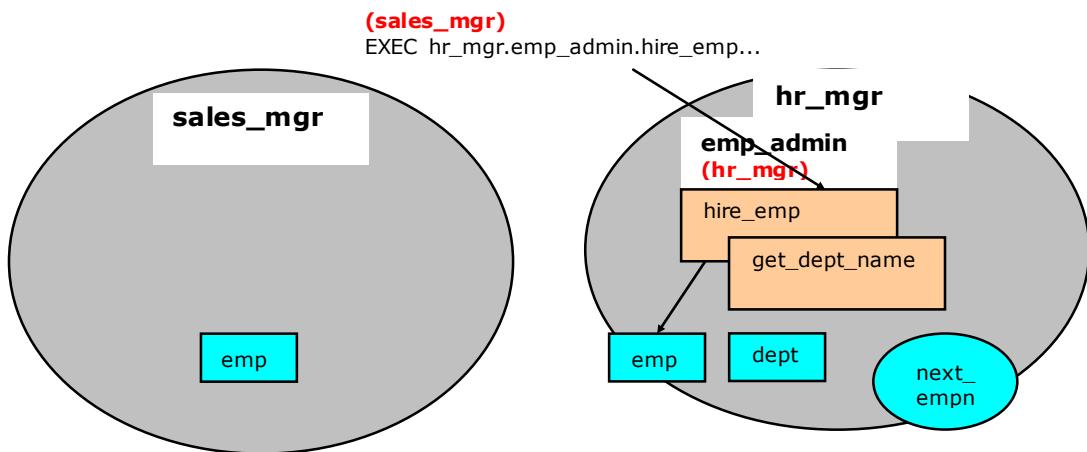


Figure 5 Definer's Rights Package

Now connect as user, `hr_mgr`. The following SELECT command verifies that the new employee was added to `hr_mgr`'s `emp` table since the `emp_admin` package has definer's rights and `hr_mgr` is `emp_admin`'s owner.

```
\c - hr_mgr
SELECT empno, ename, hiredate, sal, deptno,
hr_mgr.emp_admin.get_dept_name(deptno) FROM hr_mgr.emp;

empno | ename |      hiredate      |    sal    | deptno | get_dept_name
-----+-----+-----+-----+-----+-----+
 7369 | SMITH | 17-DEC-80 00:00:00 | 800.00 |     20 | RESEARCH
 7499 | ALLEN | 20-FEB-81 00:00:00 | 1600.00 |     30 | SALES
 7521 | WARD  | 22-FEB-81 00:00:00 | 1250.00 |     30 | SALES
 7566 | JONES | 02-APR-81 00:00:00 | 2975.00 |     20 | RESEARCH
 7654 | MARTIN | 28-SEP-81 00:00:00 | 1250.00 |     30 | SALES
 7698 | BLAKE | 01-MAY-81 00:00:00 | 2850.00 |     30 | SALES
 7782 | CLARK | 09-JUN-81 00:00:00 | 2450.00 |     10 | ACCOUNTING
 7788 | SCOTT | 19-APR-87 00:00:00 | 3000.00 |     20 | RESEARCH
 7839 | KING   | 17-NOV-81 00:00:00 | 5000.00 |     10 | ACCOUNTING
 7844 | TURNER | 08-SEP-81 00:00:00 | 1500.00 |     30 | SALES
 7876 | ADAMS | 23-MAY-87 00:00:00 | 1100.00 |     20 | RESEARCH
 7900 | JAMES | 03-DEC-81 00:00:00 | 950.00 |     30 | SALES
 7902 | FORD   | 03-DEC-81 00:00:00 | 3000.00 |     20 | RESEARCH
 7934 | MILLER | 23-JAN-82 00:00:00 | 1300.00 |     10 | ACCOUNTING
 9001 | ALICE | 08-NOV-07 00:00:00 | 8000.00 |     40 | OPERATIONS
(15 rows)
```

3.3 Variable Declarations

SPL is a block-structured language. The first section that can appear in a block is the declaration. The declaration contains the definition of variables, cursors, and other types that can be used in SPL statements contained in the block.

3.3.1 Declaring a Variable

Generally, all variables used in a block must be declared in the declaration section of the block. A variable declaration consists of a name that is assigned to the variable and its data type. Optionally, the variable can be initialized to a default value in the variable declaration.

The general syntax of a variable declaration is:

```
name type [ { := | DEFAULT } { expression | NULL } ];
```

name is an identifier assigned to the variable.

type is the data type assigned to the variable.

[:= *expression*], if given, specifies the initial value assigned to the variable when the block is entered. If the clause is not given then the variable is initialized to the SQL NULL value.

The default value is evaluated every time the block is entered. So, for example, assigning SYSDATE to a variable of type DATE causes the variable to have the time of the current invocation, not the time when the procedure or function was precompiled.

The following procedure illustrates some variable declarations that utilize defaults consisting of string and numeric expressions.

```
CREATE OR REPLACE PROCEDURE dept_salary_rpt (
    p_deptno      NUMBER
)
IS
    todays_date    DATE := SYSDATE;
    rpt_title      VARCHAR2(60) := 'Report For Department #' || p_deptno
                                || ' on ' || todays_date;
    base_sal       INTEGER := 35525;
    base_comm_rate NUMBER := 1.33333;
    base_annual    NUMBER := ROUND(base_sal * base_comm_rate, 2);
BEGIN
    DBMS_OUTPUT.PUT_LINE(rpt_title);
    DBMS_OUTPUT.PUT_LINE('Base Annual Salary: ' || base_annual);
```

```
END;
```

The following output of the above procedure shows that default values in the variable declarations are indeed assigned to the variables.

```
EXEC dept_salary_rpt(20);  
Report For Department # 20 on 10-JUL-07 16:44:45  
Base Annual Salary: 47366.55
```

3.3.2 Using %TYPE in Variable Declarations

Often, variables will be declared in SPL programs that will be used to hold values from tables in the database. In order to ensure compatibility between the table columns and the SPL variables, the data types of the two should be the same.

However, as quite often happens, a change might be made to the table definition. If the data type of the column is changed, the corresponding change may be required to the variable in the SPL program.

Instead of coding the specific column data type into the variable declaration the column attribute, `%TYPE`, can be used instead. A qualified column name in dot notation or the name of a previously declared variable must be specified as a prefix to `%TYPE`. The data type of the column or variable prefixed to `%TYPE` is assigned to the variable being declared. If the data type of the given column or variable changes, the new data type will be associated with the variable without the need to modify the declaration code.

Note: The `%TYPE` attribute can be used with formal parameter declarations as well.

```
name { { table | view }.column | variable }%TYPE;
```

name is the identifier assigned to the variable or formal parameter that is being declared. *column* is the name of a column in *table* or *view*. *variable* is the name of a variable that was declared prior to the variable identified by *name*.

Note: The variable does not inherit any of the column's other attributes such as might be specified on the column with the NOT NULL clause or the DEFAULT clause.

In the following example a procedure queries the `emp` table using an employee number, displays the employee's data, finds the average salary of all employees in the department to which the employee belongs, and then compares the chosen employee's salary with the department average.

```
CREATE OR REPLACE PROCEDURE emp_sal_query (
    p_empno      IN NUMBER
)
IS
    v_ename        VARCHAR2(10);
    v_job          VARCHAR2(9);
    v_hiredate     DATE;
    v_sal           NUMBER(7, 2);
    v_deptno       NUMBER(2);
    v_avgsal       NUMBER(7, 2);
BEGIN
    SELECT ename, job, hiredate, sal, deptno
        INTO v_ename, v_job, v_hiredate, v_sal, v_deptno
        FROM emp WHERE empno = p_empno;
```

```

DBMS_OUTPUT.PUT_LINE('Employee # : ' || p_empno);
DBMS_OUTPUT.PUT_LINE('Name      : ' || v_ename);
DBMS_OUTPUT.PUT_LINE('Job       : ' || v_job);
DBMS_OUTPUT.PUT_LINE('Hire Date : ' || v_hiredate);
DBMS_OUTPUT.PUT_LINE('Salary    : ' || v_sal);
DBMS_OUTPUT.PUT_LINE('Dept #   : ' || v_deptno);

SELECT AVG(sal) INTO v_avgsal
  FROM emp WHERE deptno = v_deptno;
IF v_sal > v_avgsal THEN
  DBMS_OUTPUT.PUT_LINE('Employee''s salary is more than the '
    || 'department average of ' || v_avgsal);
ELSE
  DBMS_OUTPUT.PUT_LINE('Employee''s salary does not exceed the '
    || 'department average of ' || v_avgsal);
END IF;
END;

```

Instead of the above, the procedure could be written as follows without explicitly coding the `emp` table data types into the declaration section of the procedure.

```

CREATE OR REPLACE PROCEDURE emp_sal_query (
  p_empno          IN emp.empno%TYPE
)
IS
  v_ename           emp.ename%TYPE;
  v_job             emp.job%TYPE;
  v_hiredate        emp.hiredate%TYPE;
  v_sal             emp.sal%TYPE;
  v_deptno          emp.deptno%TYPE;
  v_avgsal          v_sal%TYPE;
BEGIN
  SELECT ename, job, hiredate, sal, deptno
    INTO v_ename, v_job, v_hiredate, v_sal, v_deptno
    FROM emp WHERE empno = p_empno;
  DBMS_OUTPUT.PUT_LINE('Employee # : ' || p_empno);
  DBMS_OUTPUT.PUT_LINE('Name      : ' || v_ename);
  DBMS_OUTPUT.PUT_LINE('Job       : ' || v_job);
  DBMS_OUTPUT.PUT_LINE('Hire Date : ' || v_hiredate);
  DBMS_OUTPUT.PUT_LINE('Salary    : ' || v_sal);
  DBMS_OUTPUT.PUT_LINE('Dept #   : ' || v_deptno);

  SELECT AVG(sal) INTO v_avgsal
    FROM emp WHERE deptno = v_deptno;
  IF v_sal > v_avgsal THEN
    DBMS_OUTPUT.PUT_LINE('Employee''s salary is more than the '
      || 'department average of ' || v_avgsal);
  ELSE
    DBMS_OUTPUT.PUT_LINE('Employee''s salary does not exceed the '
      || 'department average of ' || v_avgsal);
  END IF;
END;

```

Note: `p_empno` shows an example of a formal parameter defined using `%TYPE`.

`v_avgsal` illustrates the usage of `%TYPE` referring to another variable instead of a table column.

The following is sample output from executing this procedure.

```
EXEC emp_sal_query(7698);

Employee # : 7698
Name       : BLAKE
Job        : MANAGER
Hire Date  : 01-MAY-81 00:00:00
Salary     : 2850.00
Dept #    : 30
Employee's salary is more than the department average of 1566.67
```

3.3.3 Using %ROWTYPE in Record Declarations

The `%TYPE` attribute provides an easy way to create a variable dependent upon a column's data type. Using the `%ROWTYPE` attribute, you can define a record that contains fields that correspond to all columns of a given table. Each field takes on the data type of its corresponding column. The fields in the record do not inherit any of the columns' other attributes such as might be specified with the `NOT NULL` clause or the `DEFAULT` clause.

A *record* is a named, ordered collection of fields. A *field* is similar to a variable; it has an identifier and data type, but has the additional property of belonging to a record, and must be referenced using dot notation with the record name as its qualifier.

You can use the `%ROWTYPE` attribute to declare a record. The `%ROWTYPE` attribute is prefixed by a table name. Each column in the named table defines an identically named field in the record with the same data type as the column.

```
record table%ROWTYPE;
```

record is an identifier assigned to the record. *table* is the name of a table (or view) whose columns are to define the fields in the record. The following example shows how the `emp_sal_query` procedure from the prior section can be modified to use `emp%ROWTYPE` to create a record named `r_emp` instead of declaring individual variables for the columns in `emp`.

```
CREATE OR REPLACE PROCEDURE emp_sal_query (
    p_empno          IN emp.empno%TYPE
)
IS
    r_emp            emp%ROWTYPE;
    v_avgsal        emp.sal%TYPE;
BEGIN
    SELECT ename, job, hiredate, sal, deptno
        INTO r_emp.ename, r_emp.job, r_emp.hiredate, r_emp.sal, r_emp.deptno
        FROM emp WHERE empno = p_empno;
    DBMS_OUTPUT.PUT_LINE('Employee # : ' || p_empno);
    DBMS_OUTPUT.PUT_LINE('Name      : ' || r_emp.ename);
    DBMS_OUTPUT.PUT_LINE('Job       : ' || r_emp.job);
    DBMS_OUTPUT.PUT_LINE('Hire Date : ' || r_emp.hiredate);
    DBMS_OUTPUT.PUT_LINE('Salary    : ' || r_emp.sal);
    DBMS_OUTPUT.PUT_LINE('Dept #   : ' || r_emp.deptno);
    SELECT AVG(sal) INTO v_avgsal
        FROM emp WHERE deptno = r_emp.deptno;
    IF r_emp.sal > v_avgsal THEN
        DBMS_OUTPUT.PUT_LINE('Employee''s salary is more than the '
            || 'department average of ' || v_avgsal);
    ELSE
        DBMS_OUTPUT.PUT_LINE('Employee''s salary does not exceed the '
            || 'department average of ' || v_avgsal);
    END IF;
END;
```

3.3.4 User-Defined Record Types and Record Variables

Records can be declared based upon a table definition using the %ROWTYPE attribute as shown in Section 3.3.3. This section describes how a new record structure can be defined that is not tied to any particular table definition.

The TYPE IS RECORD statement is used to create the definition of a record type. A *record type* is a definition of a record comprised of one or more identifiers and their corresponding data types. A record type cannot, by itself, be used to manipulate data.

The syntax for a TYPE IS RECORD statement is:

```
TYPE rec_type IS RECORD ( fields )
```

Where *fields* is a comma-separated list of one or more field definitions of the following form:

```
field_name data_type [NOT NULL] [{:= | DEFAULT} default_value]
```

Where:

rec_type

rec_type is an identifier assigned to the record type.

field_name

field_name is the identifier assigned to the field of the record type.

data_type

data_type specifies the data type of *field_name*.

DEFAULT *default_value*

The DEFAULT clause assigns a default data value for the corresponding field. The data type of the default expression must match the data type of the column. If no default is specified, then the default is NULL.

A *record variable* or simply put, a *record*, is an instance of a record type. A record is declared from a record type. The properties of the record such as its field names and types are inherited from the record type.

The following is the syntax for a record declaration.

```
record rectype
```

record is an identifier assigned to the record variable. *rectype* is the identifier of a previously defined record type. Once declared, a record can then be used to hold data.

Dot notation is used to make reference to the fields in the record.

```
record.field
```

record is a previously declared record variable and *field* is the identifier of a field belonging to the record type from which *record* is defined.

The `emp_sal_query` is again modified – this time using a user-defined record type and record variable.

```
CREATE OR REPLACE PROCEDURE emp_sal_query (
    p_empno          IN emp.empno%TYPE
)
IS
    TYPE emp_typ IS RECORD (
        ename      emp.ename%TYPE,
        job        emp.job%TYPE,
        hiredate   emp.hiredate%TYPE,
        sal         emp.sal%TYPE,
        deptno     emp.deptno%TYPE
    );
    r_emp          emp_typ;
    v_avgsal      emp.sal%TYPE;
BEGIN
    SELECT ename, job, hiredate, sal, deptno
        INTO r_emp.ename, r_emp.job, r_emp.hiredate, r_emp.sal, r_emp.deptno
        FROM emp WHERE empno = p_empno;
    DBMS_OUTPUT.PUT_LINE('Employee # : ' || p_empno);
    DBMS_OUTPUT.PUT_LINE('Name      : ' || r_emp.ename);
    DBMS_OUTPUT.PUT_LINE('Job       : ' || r_emp.job);
    DBMS_OUTPUT.PUT_LINE('Hire Date : ' || r_emp.hiredate);
    DBMS_OUTPUT.PUT_LINE('Salary    : ' || r_emp.sal);
    DBMS_OUTPUT.PUT_LINE('Dept #   : ' || r_emp.deptno);

    SELECT AVG(sal) INTO v_avgsal
        FROM emp WHERE deptno = r_emp.deptno;
    IF r_emp.sal > v_avgsal THEN
        DBMS_OUTPUT.PUT_LINE('Employee''s salary is more than the '
            || 'department average of ' || v_avgsal);
    ELSE
        DBMS_OUTPUT.PUT_LINE('Employee''s salary does not exceed the '
            || 'department average of ' || v_avgsal);
    END IF;
END;
```

Note that instead of specifying datatype names, the %TYPE attribute can be used for the field data types in the record type definition.

The following is the output from executing this stored procedure.

```
EXEC emp_sal_query(7698);

Employee # : 7698
Name       : BLAKE
Job        : MANAGER
Hire Date  : 01-MAY-81 00:00:00
Salary     : 2850.00
Dept #    : 30
Employee's salary is more than the department average of 1566.67
```

3.4 Basic Statements

This section begins the discussion of the programming statements that can be used in an SPL program.

3.4.1 NULL

The simplest statement is the `NULL` statement. This statement is an executable statement that does nothing.

```
NULL;
```

The following is the simplest, possible valid SPL program.

```
BEGIN
    NULL;
END;
```

The `NULL` statement can act as a placeholder where an executable statement is required such as in a branch of an `IF-THEN-ELSE` statement.

For example:

```
CREATE OR REPLACE PROCEDURE divide_it (
    p_numerator      IN NUMBER,
    p_denominator   IN NUMBER,
    p_result        OUT NUMBER
)
IS
BEGIN
    IF p_denominator = 0 THEN
        NULL;
    ELSE
        p_result := p_numerator / p_denominator;
    END IF;
END;
```

3.4.2 Assignment

The assignment statement sets a variable or a formal parameter of mode `OUT` or `IN OUT` specified on the left side of the assignment, `$:$ =`, to the evaluated expression specified on the right side of the assignment.

```
variable := expression;
```

`variable` is an identifier for a previously declared variable, `OUT` formal parameter, or `IN OUT` formal parameter.

expression is an expression that produces a single value. The value produced by the expression must have a compatible data type with that of *variable*.

The following example shows the typical use of assignment statements in the executable section of the procedure.

```

CREATE OR REPLACE PROCEDURE dept_salary_rpt (
    p_deptno      NUMBER
)
IS
    todays_date    DATE;
    rpt_title      VARCHAR2(60);
    base_sal       INTEGER;
    base_comm_rate NUMBER;
    base_annual    NUMBER;
BEGIN
    todays_date := SYSDATE;
    rpt_title := 'Report For Department #' || p_deptno || ' on '
        || todays_date;
    base_sal := 35525;
    base_comm_rate := 1.33333;
    base_annual := ROUND(base_sal * base_comm_rate, 2);

    DBMS_OUTPUT.PUT_LINE(rpt_title);
    DBMS_OUTPUT.PUT_LINE('Base Annual Salary: ' || base_annual);
END;

```

3.4.3 SELECT INTO

The `SELECT INTO` statement is an SPL variation of the SQL `SELECT` command, the differences being:

- That `SELECT INTO` is designed to assign the results to variables or records where they can then be used in SPL program statements.
- The accessible result set of `SELECT INTO` is at most one row.

Other than the above, all of the clauses of the `SELECT` command such as `WHERE`, `ORDER BY`, `GROUP BY`, `HAVING`, etc. are valid for `SELECT INTO`. The following are the two variations of `SELECT INTO`.

```
SELECT select_expressions INTO target FROM ...;
```

target is a comma-separated list of simple variables. *select_expressions* and the remainder of the statement are the same as for the `SELECT` command. The selected values must exactly match in data type, number, and order the structure of the target or a runtime error occurs.

```
SELECT * INTO record FROM table ...;
```

record is a record variable that has previously been declared.

If the query returns zero rows, null values are assigned to the target(s). If the query returns multiple rows, the first row is assigned to the target(s) and the rest are discarded. (Note that "the first row" is not well-defined unless you've used ORDER BY.)

Note: In either cases, where no row is returned or more than one row is returned, SPL throws an exception.

Note: There is a variation of SELECT INTO using the BULK COLLECT clause that allows a result set of more than one row that is returned into a collection. See Section [3.12.4.1](#) for more information on using the BULK COLLECT clause with the SELECT INTO statement.

You can use the WHEN NO_DATA_FOUND clause in an EXCEPTION block to determine whether the assignment was successful (that is, at least one row was returned by the query).

This version of the emp_sal_query procedure uses the variation of SELECT INTO that returns the result set into a record. Also note the addition of the EXCEPTION block containing the WHEN NO_DATA_FOUND conditional expression.

```

CREATE OR REPLACE PROCEDURE emp_sal_query (
    p_empno          IN emp.empno%TYPE
)
IS
    r_emp            emp%ROWTYPE;
    v_avgsal        emp.sal%TYPE;
BEGIN
    SELECT * INTO r_emp
        FROM emp WHERE empno = p_empno;
    DBMS_OUTPUT.PUT_LINE('Employee # : ' || p_empno);
    DBMS_OUTPUT.PUT_LINE('Name      : ' || r_emp.ename);
    DBMS_OUTPUT.PUT_LINE('Job       : ' || r_emp.job);
    DBMS_OUTPUT.PUT_LINE('Hire Date : ' || r_emp.hiredate);
    DBMS_OUTPUT.PUT_LINE('Salary    : ' || r_emp.sal);
    DBMS_OUTPUT.PUT_LINE('Dept #   : ' || r_emp.deptno);

    SELECT AVG(sal) INTO v_avgsal
        FROM emp WHERE deptno = r_emp.deptno;
    IF r_emp.sal > v_avgsal THEN
        DBMS_OUTPUT.PUT_LINE('Employee''s salary is more than the '
        || 'department average of ' || v_avgsal);
    ELSE
        DBMS_OUTPUT.PUT_LINE('Employee''s salary does not exceed the '
        || 'department average of ' || v_avgsal);
    END IF;
EXCEPTION
    WHEN NO_DATA_FOUND THEN
        DBMS_OUTPUT.PUT_LINE('Employee # ' || p_empno || ' not found');
END;

```

If the query is executed with a non-existent employee number the results appear as follows.

```
EXEC emp_sal_query(0);

Employee # 0 not found
```

Another conditional clause of use in the EXCEPTION section with SELECT INTO is the TOO_MANY_ROWS exception. If more than one row is selected by the SELECT INTO statement an exception is thrown by SPL.

When the following block is executed, the TOO_MANY_ROWS exception is thrown since there are many employees in the specified department.

```
DECLARE
    v_ename          emp.ename%TYPE;
BEGIN
    SELECT ename INTO v_ename FROM emp WHERE deptno = 20 ORDER BY ename;
EXCEPTION
    WHEN TOO_MANY_ROWS THEN
        DBMS_OUTPUT.PUT_LINE('More than one employee found');
        DBMS_OUTPUT.PUT_LINE('First employee returned is ' || v_ename);
END;

More than one employee found
First employee returned is ADAMS
```

Note: See Section [3.5.7](#) or more information on exception handling.

3.4.4 INSERT

The INSERT command available in the SQL language can also be used in SPL programs.

An expression in the SPL language can be used wherever an expression is allowed in the SQL INSERT command. Thus, SPL variables and parameters can be used to supply values to the insert operation.

The following is an example of a procedure that performs an insert of a new employee using data passed from a calling program.

```
CREATE OR REPLACE PROCEDURE emp_insert (
    p_empno      IN emp.empno%TYPE,
    p_ename       IN emp.ename%TYPE,
    p_job         IN emp.job%TYPE,
    p_mgr         IN emp.mgr%TYPE,
    p_hiredate   IN emp.hiredate%TYPE,
    p_sal         IN emp.sal%TYPE,
    p_comm        IN emp.comm%TYPE,
    p_deptno     IN emp.deptno%TYPE
)
IS
BEGIN
    INSERT INTO emp VALUES (
        p_empno,
        p_ename,
        p_job,
        p_mgr,
        p_hiredate,
```

```

    p_sal,
    p_comm,
    p_deptno);

    DBMS_OUTPUT.PUT_LINE('Added employee...');
    DBMS_OUTPUT.PUT_LINE('Employee # : ' || p_empno);
    DBMS_OUTPUT.PUT_LINE('Name      : ' || p_ename);
    DBMS_OUTPUT.PUT_LINE('Job       : ' || p_job);
    DBMS_OUTPUT.PUT_LINE('Manager   : ' || p_mgr);
    DBMS_OUTPUT.PUT_LINE('Hire Date : ' || p_hiredate);
    DBMS_OUTPUT.PUT_LINE('Salary    : ' || p_sal);
    DBMS_OUTPUT.PUT_LINE('Commission: ' || p_comm);
    DBMS_OUTPUT.PUT_LINE('Dept #   : ' || p_deptno);
    DBMS_OUTPUT.PUT_LINE('-----');

EXCEPTION
    WHEN OTHERS THEN
        DBMS_OUTPUT.PUT_LINE('OTHERS exception on INSERT of employee #' ||
                             ' || p_empno);
        DBMS_OUTPUT.PUT_LINE('SQLCODE : ' || SQLCODE);
        DBMS_OUTPUT.PUT_LINE('SQLERRM : ' || SQLERRM);
END;

```

If an exception occurs all database changes made in the procedure are automatically rolled back. In this example the `EXCEPTION` section with the `WHEN OTHERS` clause catches all exceptions. Two variables are displayed. `SQLCODE` is a number that identifies the specific exception that occurred. `SQLERRM` is a text message explaining the error. See Section [3.5.7](#) for more information on exception handling.

The following shows the output when this procedure is executed.

```

EXEC emp_insert(9503,'PETERSON','ANALYST',7902,'31-MAR-05',5000,NULL,40);

Added employee...
Employee # : 9503
Name      : PETERSON
Job       : ANALYST
Manager   : 7902
Hire Date : 31-MAR-05 00:00:00
Salary    : 5000
Dept #   : 40
-----
SELECT * FROM emp WHERE empno = 9503;

  empno | ename   | job    | mgr   |      hiredate     |    sal   | comm | deptno
-----+-----+-----+-----+-----+-----+-----+-----+
  9503 | PETERSON | ANALYST | 7902 | 31-MAR-05 00:00:00 | 5000.00 |    | 40
(1 row)

```

Note: The `INSERT` command can be included in a `FORALL` statement. A `FORALL` statement allows a single `INSERT` command to insert multiple rows from values supplied in one or more collections. See [3.12.3](#) for more information on the `FORALL` statement.

3.4.5 UPDATE

The `UPDATE` command available in the SQL language can also be used in SPL programs.

An expression in the SPL language can be used wherever an expression is allowed in the SQL `UPDATE` command. Thus, SPL variables and parameters can be used to supply values to the update operation.

```
CREATE OR REPLACE PROCEDURE emp_comp_update (
    p_empno          IN emp.empno%TYPE,
    p_sal            IN emp.sal%TYPE,
    p_comm           IN emp.comm%TYPE
)
IS
BEGIN
    UPDATE emp SET sal = p_sal, comm = p_comm WHERE empno = p_empno;

    IF SQL%FOUND THEN
        DBMS_OUTPUT.PUT_LINE('Updated Employee # : ' || p_empno);
        DBMS_OUTPUT.PUT_LINE('New Salary          : ' || p_sal);
        DBMS_OUTPUT.PUT_LINE('New Commission      : ' || p_comm);
    ELSE
        DBMS_OUTPUT.PUT_LINE('Employee # ' || p_empno || ' not found');
    END IF;
END;
```

The `SQL%FOUND` conditional expression returns `TRUE` if a row is updated, `FALSE` otherwise. See Section [3.4.8](#) for a discussion of `SQL%FOUND` and other similar expressions.

The following shows the update on the employee using this procedure.

```
EXEC emp_comp_update(9503, 6540, 1200);

Updated Employee # : 9503
New Salary          : 6540
New Commission      : 1200

SELECT * FROM emp WHERE empno = 9503;

empno | ename   | job    | mgr   |      hiredate     |    sal    |    comm    | deptno
-----+-----+-----+-----+-----+-----+-----+-----+
  9503 | PETERSON | ANALYST | 7902 | 31-MAR-05 00:00:00 | 6540.00 | 1200.00 |      40
(1 row)
```

Note: The `UPDATE` command can be included in a `FORALL` statement. A `FORALL` statement allows a single `UPDATE` command to update multiple rows from values supplied in one or more collections. See Section [3.12.3](#) for more information on the `FORALL` statement.

3.4.6 DELETE

The `DELETE` command (available in the SQL language) can also be used in SPL programs.

An expression in the SPL language can be used wherever an expression is allowed in the SQL `DELETE` command. Thus, SPL variables and parameters can be used to supply values to the delete operation.

```
CREATE OR REPLACE PROCEDURE emp_delete (
    p_empno          IN emp.empno%TYPE
)
IS
BEGIN
    DELETE FROM emp WHERE empno = p_empno;

    IF SQL%FOUND THEN
        DBMS_OUTPUT.PUT_LINE('Deleted Employee # : ' || p_empno);
    ELSE
        DBMS_OUTPUT.PUT_LINE('Employee # ' || p_empno || ' not found');
    END IF;
END;
```

The `SQL%FOUND` conditional expression returns `TRUE` if a row is deleted, `FALSE` otherwise. See Section [3.4.8](#) for a discussion of `SQL%FOUND` and other similar expressions.

The following shows the deletion of an employee using this procedure.

```
EXEC emp_delete(9503);

Deleted Employee # : 9503

SELECT * FROM emp WHERE empno = 9503;

empno | ename | job | mgr | hiredate | sal | comm | deptno
-----+-----+-----+-----+-----+-----+-----+
(0 rows)
```

Note: The `DELETE` command can be included in a `FORALL` statement. A `FORALL` statement allows a single `DELETE` command to delete multiple rows from values supplied in one or more collections. See Section [3.12.3](#) for more information on the `FORALL` statement.

3.4.7 Using the RETURNING INTO Clause

The `INSERT`, `UPDATE`, and `DELETE` commands may be appended by the optional `RETURNING INTO` clause. This clause allows the SPL program to capture the newly added, modified, or deleted values from the results of an `INSERT`, `UPDATE`, or `DELETE` command, respectively.

The following is the syntax.

```
{ insert | update | delete }
RETURNING { * | expr_1 [, expr_2 ] ... }
    INTO { record | field_1 [, field_2 ] ... };
```

insert is a valid `INSERT` command. *update* is a valid `UPDATE` command. *delete* is a valid `DELETE` command. If `*` is specified, then the values from the row affected by the `INSERT`, `UPDATE`, or `DELETE` command are made available for assignment to the record or fields to the right of the `INTO` keyword. (Note that the use of `*` is an Advanced Server extension and is not compatible with Oracle databases.) *expr_1*, *expr_2*... are expressions evaluated upon the row affected by the `INSERT`, `UPDATE`, or `DELETE` command. The evaluated results are assigned to the record or fields to the right of the `INTO` keyword. *record* is the identifier of a record that must contain fields that match in number and order, and are data type compatible with the values in the `RETURNING` clause. *field_1*, *field_2*... are variables that must match in number and order, and are data type compatible with the set of values in the `RETURNING` clause.

If the `INSERT`, `UPDATE`, or `DELETE` command returns a result set with more than one row, then an exception is thrown with `SQLCODE 01422`, query returned more than one row. If no rows are in the result set, then the variables following the `INTO` keyword are set to null.

Note: There is a variation of `RETURNING INTO` using the `BULK COLLECT` clause that allows a result set of more than one row that is returned into a collection. See Section 3.12.4 for more information on the `BULK COLLECT` clause.

The following example is a modification of the `emp_comp_update` procedure introduced in Section 3.4.5, with the addition of the `RETURNING INTO` clause.

```

CREATE OR REPLACE PROCEDURE emp_comp_update (
    p_empno      IN emp.empno%TYPE,
    p_sal        IN emp.sal%TYPE,
    p_comm       IN emp.comm%TYPE
)
IS
    v_empno      emp.empno%TYPE;
    vENAME      emp.ename%TYPE;
    v_job        emp.job%TYPE;
    v_sal        emp.sal%TYPE;
    v_comm       emp.comm%TYPE;
    v_deptno     emp.deptno%TYPE;
BEGIN
    UPDATE emp SET sal = p_sal, comm = p_comm WHERE empno = p_empno
    RETURNING
        empno,
        ename,
        job,
        sal,
        comm,
        deptno
    INTO
        v_empno,
        vENAME,
        v_job,
        v_sal,
        v_comm,
        v_deptno;

```

```

IF SQL%FOUND THEN
    DBMS_OUTPUT.PUT_LINE('Updated Employee # : ' || v_empno);
    DBMS_OUTPUT.PUT_LINE('Name          : ' || v_ename);
    DBMS_OUTPUT.PUT_LINE('Job           : ' || v_job);
    DBMS_OUTPUT.PUT_LINE('Department   : ' || v_deptno);
    DBMS_OUTPUT.PUT_LINE('New Salary    : ' || v_sal);
    DBMS_OUTPUT.PUT_LINE('New Commission: ' || v_comm);
ELSE
    DBMS_OUTPUT.PUT_LINE('Employee # ' || p_empno || ' not found');
END IF;
END;

```

The following is the output from this procedure (assuming employee 9503 created by the `emp_insert` procedure still exists within the table).

```

EXEC emp_comp_update(9503, 6540, 1200);

Updated Employee # : 9503
Name          : PETERSON
Job           : ANALYST
Department   : 40
New Salary    : 6540.00
New Commission: 1200.00

```

The following example is a modification of the `emp_delete` procedure, with the addition of the `RETURNING INTO` clause using record types.

```

CREATE OR REPLACE PROCEDURE emp_delete (
    p_empno      IN emp.empno%TYPE
)
IS
    r_emp        emp%ROWTYPE;
BEGIN
    DELETE FROM emp WHERE empno = p_empno
    RETURNING
        *
    INTO
        r_emp;

    IF SQL%FOUND THEN
        DBMS_OUTPUT.PUT_LINE('Deleted Employee # : ' || r_emp.empno);
        DBMS_OUTPUT.PUT_LINE('Name          : ' || r_emp.ename);
        DBMS_OUTPUT.PUT_LINE('Job           : ' || r_emp.job);
        DBMS_OUTPUT.PUT_LINE('Manager       : ' || r_emp.mgr);
        DBMS_OUTPUT.PUT_LINE('Hire Date    : ' || r_emp.hiredate);
        DBMS_OUTPUT.PUT_LINE('Salary        : ' || r_emp.sal);
        DBMS_OUTPUT.PUT_LINE('Commission   : ' || r_emp.comm);
        DBMS_OUTPUT.PUT_LINE('Department   : ' || r_emp.deptno);
    ELSE
        DBMS_OUTPUT.PUT_LINE('Employee # ' || p_empno || ' not found');
    END IF;
END;

```

The following is the output from this procedure.

```

EXEC emp_delete(9503);

Deleted Employee # : 9503
Name          : PETERSON

```

Job	:	ANALYST
Manager	:	7902
Hire Date	:	31-MAR-05 00:00:00
Salary	:	6540.00
Commission	:	1200.00
Department	:	40

3.4.8 Obtaining the Result Status

There are several attributes that can be used to determine the effect of a command. `SQL%FOUND` is a Boolean that returns `TRUE` if at least one row was affected by an `INSERT`, `UPDATE` or `DELETE` command or a `SELECT INTO` command retrieved one or more rows.

The following anonymous block inserts a row and then displays the fact that the row has been inserted.

```
BEGIN
    INSERT INTO emp (empno,ename,job,sal,deptno) VALUES (
        9001, 'JONES', 'CLERK', 850.00, 40);
    IF SQL%FOUND THEN
        DBMS_OUTPUT.PUT_LINE('Row has been inserted');
    END IF;
END;

Row has been inserted
```

`SQL%ROWCOUNT` provides the number of rows affected by an `INSERT`, `UPDATE`, `DELETE`, or `SELECT INTO` command. The `SQL%ROWCOUNT` value is returned as a `BIGINT` data type. The following example updates the row that was just inserted and displays `SQL%ROWCOUNT`.

```
BEGIN
    UPDATE emp SET hiredate = '03-JUN-07' WHERE empno = 9001;
    DBMS_OUTPUT.PUT_LINE('# rows updated: ' || SQL%ROWCOUNT);
END;

# rows updated: 1
```

`SQL%NOTFOUND` is the opposite of `SQL%FOUND`. `SQL%NOTFOUND` returns `TRUE` if no rows were affected by an `INSERT`, `UPDATE` or `DELETE` command or a `SELECT INTO` command retrieved no rows.

```
BEGIN
    UPDATE emp SET hiredate = '03-JUN-07' WHERE empno = 9000;
    IF SQL%NOTFOUND THEN
        DBMS_OUTPUT.PUT_LINE('No rows were updated');
    END IF;
END;

No rows were updated
```

3.5 Control Structures

The programming statements in SPL that make it a full procedural complement to SQL are described in this section.

3.5.1 IF Statement

IF statements let you execute commands based on certain conditions. SPL has four forms of IF:

- IF ... THEN
- IF ... THEN ... ELSE
- IF ... THEN ... ELSE IF
- IF ... THEN ... ELSEIF ... THEN ... ELSE

3.5.1.1 IF-THEN

```
IF boolean-expression THEN
    statements
END IF;
```

IF-THEN statements are the simplest form of IF. The statements between THEN and END IF will be executed if the condition is TRUE. Otherwise, they are skipped.

In the following example an IF-THEN statement is used to test and display employees who have a commission.

```
DECLARE
    v_empno      emp.empno%TYPE;
    v_comm       emp.comm%TYPE;
    CURSOR emp_cursor IS SELECT empno, comm FROM emp;
BEGIN
    OPEN emp_cursor;
    DBMS_OUTPUT.PUT_LINE('EMPNO      COMM');
    DBMS_OUTPUT.PUT_LINE('-----      -----');
    LOOP
        FETCH emp_cursor INTO v_empno, v_comm;
        EXIT WHEN emp_cursor%NOTFOUND;
    --
    -- Test whether or not the employee gets a commission
    --
        IF v_comm IS NOT NULL AND v_comm > 0 THEN
            DBMS_OUTPUT.PUT_LINE(v_empno || ' ' ||
                TO_CHAR(v_comm,'$99999.99'));
        END IF;
    END LOOP;
    CLOSE emp_cursor;
END;
```

The following is the output from this program.

EMPNO	COMM
7499	\$300.00
7521	\$500.00
7654	\$1400.00

3.5.1.2 IF-THEN-ELSE

```
IF boolean-expression THEN
    statements
ELSE
    statements
END IF;
```

IF-THEN-ELSE statements add to IF-THEN by letting you specify an alternative set of statements that should be executed if the condition evaluates to false.

The previous example is modified so an IF-THEN-ELSE statement is used to display the text Non-commission if the employee does not get a commission.

```
DECLARE
    v_empno        emp.empno%TYPE;
    v_comm         emp.comm%TYPE;
    CURSOR emp_cursor IS SELECT empno, comm FROM emp;
BEGIN
    OPEN emp_cursor;
    DBMS_OUTPUT.PUT_LINE('EMPNO      COMM');
    DBMS_OUTPUT.PUT_LINE('-----  -----');
    LOOP
        FETCH emp_cursor INTO v_empno, v_comm;
        EXIT WHEN emp_cursor%NOTFOUND;
    --
    -- Test whether or not the employee gets a commission
    --
        IF v_comm IS NOT NULL AND v_comm > 0 THEN
            DBMS_OUTPUT.PUT_LINE(v_empno || ' ' || 
                TO_CHAR(v_comm,'$99999.99'));
        ELSE
            DBMS_OUTPUT.PUT_LINE(v_empno || ' ' || 'Non-commission');
        END IF;
    END LOOP;
    CLOSE emp_cursor;
END;
```

The following is the output from this program.

EMPNO	COMM
7369	Non-commission
7499	\$ 300.00
7521	\$ 500.00
7566	Non-commission
7654	\$ 1400.00

```

7698      Non-commission
7782      Non-commission
7788      Non-commission
7839      Non-commission
7844      Non-commission
7876      Non-commission
7900      Non-commission
7902      Non-commission
7934      Non-commission

```

3.5.1.3 IF-THEN-ELSE IF

IF statements can be nested so that alternative IF statements can be invoked once it is determined whether or not the conditional of an outer IF statement is TRUE or FALSE.

In the following example the outer IF-THEN-ELSE statement tests whether or not an employee has a commission. The inner IF-THEN-ELSE statements then test whether the employee's total compensation exceeds or is less than the company average.

```

DECLARE
    v_empno        emp.empno%TYPE;
    v_sal          emp.sal%TYPE;
    v_comm         emp.comm%TYPE;
    v_avg          NUMBER(7,2);
    CURSOR emp_cursor IS SELECT empno, sal, comm FROM emp;
BEGIN
    --
    -- Calculate the average yearly compensation in the company
    --
    SELECT AVG((sal + NVL(comm,0)) * 24) INTO v_avg FROM emp;
    DBMS_OUTPUT.PUT_LINE('Average Yearly Compensation: ' ||
                          TO_CHAR(v_avg,'$999,999.99'));
    OPEN emp_cursor;
    DBMS_OUTPUT.PUT_LINE('EMPNO      YEARLY COMP');
    DBMS_OUTPUT.PUT_LINE('-----  -----');
    LOOP
        FETCH emp_cursor INTO v_empno, v_sal, v_comm;
        EXIT WHEN emp_cursor%NOTFOUND;
    --
    -- Test whether or not the employee gets a commission
    --
        IF v_comm IS NOT NULL AND v_comm > 0 THEN
            --
            -- Test if the employee's compensation with commission exceeds the average
            --
                IF (v_sal + v_comm) * 24 > v_avg THEN
                    DBMS_OUTPUT.PUT_LINE(v_empno || ' ' ||
                                         TO_CHAR((v_sal + v_comm) * 24,'$999,999.99') ||
                                         ' Exceeds Average');
                ELSE
                    DBMS_OUTPUT.PUT_LINE(v_empno || ' ' ||
                                         TO_CHAR((v_sal + v_comm) * 24,'$999,999.99') ||
                                         ' Below Average');
                END IF;
            ELSE
                --
                -- Test if the employee's compensation without commission exceeds the
                -- average
                --

```

```

        IF v_sal * 24 > v_avg THEN
            DBMS_OUTPUT.PUT_LINE(v_empno || ' ' ||
                TO_CHAR(v_sal * 24, '$999,999.99') || ' Exceeds Average');
        ELSE
            DBMS_OUTPUT.PUT_LINE(v_empno || ' ' ||
                TO_CHAR(v_sal * 24, '$999,999.99') || ' Below Average');
        END IF;
    END IF;
END LOOP;
CLOSE emp_cursor;
END;

```

Note: The logic in this program can be simplified considerably by calculating the employee's yearly compensation using the NVL function within the SELECT command of the cursor declaration, however, the purpose of this example is to demonstrate how IF statements can be used.

The following is the output from this program.

Average Yearly Compensation: \$ 53,528.57	
EMPNO	YEARLY COMP
7369	\$ 19,200.00 Below Average
7499	\$ 45,600.00 Below Average
7521	\$ 42,000.00 Below Average
7566	\$ 71,400.00 Exceeds Average
7654	\$ 63,600.00 Exceeds Average
7698	\$ 68,400.00 Exceeds Average
7782	\$ 58,800.00 Exceeds Average
7788	\$ 72,000.00 Exceeds Average
7839	\$ 120,000.00 Exceeds Average
7844	\$ 36,000.00 Below Average
7876	\$ 26,400.00 Below Average
7900	\$ 22,800.00 Below Average
7902	\$ 72,000.00 Exceeds Average
7934	\$ 31,200.00 Below Average

When you use this form, you are actually nesting an IF statement inside the ELSE part of an outer IF statement. Thus you need one END IF statement for each nested IF and one for the parent IF-ELSE.

3.5.1.4 IF-THEN-ELSIF-ELSE

```

IF boolean-expression THEN
    statements
[ ELSIF boolean-expression THEN
    statements
[ ELSIF boolean-expression THEN
    statements ] ...]
[ ELSE
    statements ]
END IF;

```

`IF-THEN-ELSIF-ELSE` provides a method of checking many alternatives in one statement. Formally it is equivalent to nested `IF-THEN-ELSE-IF-THEN` commands, but only one `END IF` is needed.

The following example uses an `IF-THEN-ELSIF-ELSE` statement to count the number of employees by compensation ranges of \$25,000.

```

DECLARE
    v_empno      emp.empno%TYPE;
    v_comp        NUMBER(8,2);
    v_lt_25K     SMALLINT := 0;
    v_25K_50K    SMALLINT := 0;
    v_50K_75K    SMALLINT := 0;
    v_75K_100K   SMALLINT := 0;
    v_ge_100K    SMALLINT := 0;
    CURSOR emp_cursor IS SELECT empno, (sal + NVL(comm,0)) * 24 FROM emp;
BEGIN
    OPEN emp_cursor;
    LOOP
        FETCH emp_cursor INTO v_empno, v_comp;
        EXIT WHEN emp_cursor%NOTFOUND;
        IF v_comp < 25000 THEN
            v_lt_25K := v_lt_25K + 1;
        ELSIF v_comp < 50000 THEN
            v_25K_50K := v_25K_50K + 1;
        ELSIF v_comp < 75000 THEN
            v_50K_75K := v_50K_75K + 1;
        ELSIF v_comp < 100000 THEN
            v_75K_100K := v_75K_100K + 1;
        ELSE
            v_ge_100K := v_ge_100K + 1;
        END IF;
    END LOOP;
    CLOSE emp_cursor;
    DBMS_OUTPUT.PUT_LINE('Number of employees by yearly compensation');
    DBMS_OUTPUT.PUT_LINE('Less than 25,000 : ' || v_lt_25K);
    DBMS_OUTPUT.PUT_LINE('25,000 - 49,9999 : ' || v_25K_50K);
    DBMS_OUTPUT.PUT_LINE('50,000 - 74,9999 : ' || v_50K_75K);
    DBMS_OUTPUT.PUT_LINE('75,000 - 99,9999 : ' || v_75K_100K);
    DBMS_OUTPUT.PUT_LINE('100,000 and over : ' || v_ge_100K);
END;

```

The following is the output from this program.

```

Number of employees by yearly compensation
Less than 25,000 : 2
25,000 - 49,9999 : 5
50,000 - 74,9999 : 6
75,000 - 99,9999 : 0
100,000 and over : 1

```

3.5.2 RETURN Statement

The `RETURN` statement terminates the current function, procedure or anonymous block and returns control to the caller.

There are two forms of the `RETURN` Statement. The first form of the `RETURN` statement is used to terminate a procedure or function that returns `void`. The syntax of the first form is:

```
RETURN;
```

The second form of `RETURN` returns a value to the caller. The syntax of the second form of the `RETURN` statement is:

```
RETURN expression;
```

expression must evaluate to the same data type as the return type of the function.

The following example uses the `RETURN` statement returns a value to the caller:

```
CREATE OR REPLACE FUNCTION emp_comp (
    p_sal          NUMBER,
    p_comm         NUMBER
) RETURN NUMBER
IS
BEGIN
    RETURN (p_sal + NVL(p_comm, 0)) * 24;
END emp_comp;
```

3.5.3 GOTO Statement

The `GOTO` statement causes the point of execution to jump to the statement with the specified label. The syntax of a `GOTO` statement is:

```
GOTO label
```

`label` is a name assigned to an executable statement. `label` must be unique within the scope of the function, procedure or anonymous block.

To label a statement, use the syntax

```
<<label>> statement
```

`statement` is the point of execution that the program jumps to.

You can label assignment statements, any SQL statement (like `INSERT`, `UPDATE`, `CREATE`, etc.) and selected procedural language statements. The procedural language statements that can be labeled are:

- `IF`
- `EXIT`
- `RETURN`
- `RAISE`
- `EXECUTE`
- `PERFORM`
- `GET DIAGNOSTICS`
- `OPEN`
- `FETCH`
- `MOVE`
- `CLOSE`
- `NULL`
- `COMMIT`
- `ROLLBACK`
- `GOTO`
- `CASE`
- `LOOP`
- `WHILE`
- `FOR`

Please note that `exit` is considered a keyword, and cannot be used as the name of a label.

`GOTO` statements cannot transfer control *into* a conditional block or sub-block, but can transfer control *from* a conditional block or sub-block.

The following example verifies that an employee record contains a name, job description, and employee hire date; if any piece of information is missing, a `GOTO` statement transfers the point of execution to a statement that prints a message that the employee is not valid.

```

CREATE OR REPLACE PROCEDURE verify_emp (
    p_empno          NUMBER
)
IS
    v_ename          emp.ename%TYPE;
    v_job            emp.job%TYPE;
    v_hiredate       emp.hiredate%TYPE;
BEGIN
    SELECT ename, job, hiredate
        INTO v_ename, v_job, v_hiredate FROM emp
        WHERE empno = p_empno;
    IF v_ename IS NULL THEN
        GOTO invalid_emp;
    END IF;
    IF v_job IS NULL THEN
        GOTO invalid_emp;
    END IF;
    IF v_hiredate IS NULL THEN
        GOTO invalid_emp;
    END IF;
    DBMS_OUTPUT.PUT_LINE('Employee ' || p_empno ||
        ' validated without errors.');
    RETURN;
<<invalid_emp>> DBMS_OUTPUT.PUT_LINE('Employee ' || p_empno ||
        ' is not a valid employee.');
END;

```

`GOTO` statements have the following restrictions:

- A `GOTO` statement cannot jump to a declaration.
- A `GOTO` statement cannot transfer control to another function or procedure.
- A `label` should not be placed at the end of a block, function or procedure.

3.5.4 CASE Expression

The `CASE` expression returns a value that is substituted where the `CASE` expression is located within an expression.

There are two formats of the `CASE` expression - one that is called a *searched CASE* and the other that uses a *selector*.

3.5.4.1 Selector CASE Expression

The selector `CASE` expression attempts to match an expression called the selector to the expression specified in one or more `WHEN` clauses. `result` is an expression that is type-compatible in the context where the `CASE` expression is used. If a match is found, the value given in the corresponding `THEN` clause is returned by the `CASE` expression. If there are no matches, the value following `ELSE` is returned. If `ELSE` is omitted, the `CASE` expression returns null.

```
CASE selector-expression
    WHEN match-expression THEN
        result
    [ WHEN match-expression THEN
        result
    [ WHEN match-expression THEN
        result ] ... ]
    [ ELSE
        result ]
END;
```

`match-expression` is evaluated in the order in which it appears within the `CASE` expression. `result` is an expression that is type-compatible in the context where the `CASE` expression is used. When the first `match-expression` is encountered that equals `selector-expression`, `result` in the corresponding `THEN` clause is returned as the value of the `CASE` expression. If none of `match-expression` equals `selector-expression` then `result` following `ELSE` is returned. If no `ELSE` is specified, the `CASE` expression returns null.

The following example uses a selector `CASE` expression to assign the department name to a variable based upon the department number.

```
DECLARE
    v_empno      emp.empno%TYPE;
    v_ename       emp.ename%TYPE;
    v_deptno     emp.deptno%TYPE;
    v_dname       dept.dname%TYPE;
    CURSOR emp_cursor IS SELECT empno, ename, deptno FROM emp;
BEGIN
    OPEN emp_cursor;
```

```

DBMS_OUTPUT.PUT_LINE('EMPNO      ENAME      DEPTNO      DNAME');
DBMS_OUTPUT.PUT_LINE('-----  -----  -----  -----');
LOOP
  FETCH emp_cursor INTO v_empno, v_ename, v_deptno;
  EXIT WHEN emp_cursor%NOTFOUND;
  v_dname :=  

    CASE v_deptno
      WHEN 10 THEN 'Accounting'
      WHEN 20 THEN 'Research'
      WHEN 30 THEN 'Sales'
      WHEN 40 THEN 'Operations'
      ELSE 'unknown'
    END;
  DBMS_OUTPUT.PUT_LINE(v_empno || '      ' || RPAD(v_ename, 10) ||  

    '      ' || v_deptno || '      ' || v_dname);
END LOOP;
CLOSE emp_cursor;
END;

```

The following is the output from this program.

EMPNO	ENAME	DEPTNO	DNAME
-----	-----	-----	-----
7369	SMITH	20	Research
7499	ALLEN	30	Sales
7521	WARD	30	Sales
7566	JONES	20	Research
7654	MARTIN	30	Sales
7698	BLAKE	30	Sales
7782	CLARK	10	Accounting
7788	SCOTT	20	Research
7839	KING	10	Accounting
7844	TURNER	30	Sales
7876	ADAMS	20	Research
7900	JAMES	30	Sales
7902	FORD	20	Research
7934	MILLER	10	Accounting

3.5.4.2 Searched CASE Expression

A searched CASE expression uses one or more Boolean expressions to determine the resulting value to return.

```

CASE WHEN boolean-expression THEN
  result
[ WHEN boolean-expression THEN
  result
  [ WHEN boolean-expression THEN
    result ] ...]
[ ELSE
  result ]
END;

```

boolean-expression is evaluated in the order in which it appears within the CASE expression. *result* is an expression that is type-compatible in the context where the CASE expression is used. When the first *boolean-expression* is encountered that

evaluates to TRUE, *result* in the corresponding THEN clause is returned as the value of the CASE expression. If none of *boolean-expression* evaluates to true then *result* following ELSE is returned. If no ELSE is specified, the CASE expression returns null.

The following example uses a searched CASE expression to assign the department name to a variable based upon the department number.

```

DECLARE
    v_empno      emp.empno%TYPE;
    v_ename       emp.ename%TYPE;
    v_deptno     emp.deptno%TYPE;
    v_dname       dept.dname%TYPE;
    CURSOR emp_cursor IS SELECT empno, ename, deptno FROM emp;
BEGIN
    OPEN emp_cursor;
    DBMS_OUTPUT.PUT_LINE('EMPNO      ENAME      DEPTNO      DNAME');
    DBMS_OUTPUT.PUT_LINE('-----  -----  -----  -----');
    LOOP
        FETCH emp_cursor INTO v_empno, v_ename, v_deptno;
        EXIT WHEN emp_cursor%NOTFOUND;
        v_dname := 
            CASE
                WHEN v_deptno = 10 THEN 'Accounting'
                WHEN v_deptno = 20 THEN 'Research'
                WHEN v_deptno = 30 THEN 'Sales'
                WHEN v_deptno = 40 THEN 'Operations'
                ELSE 'unknown'
            END;
        DBMS_OUTPUT.PUT_LINE(v_empno || '      ' || RPAD(v_ename, 10) ||
            '      ' || v_deptno || '      ' || v_dname);
    END LOOP;
    CLOSE emp_cursor;
END;

```

The following is the output from this program.

EMPNO	ENAME	DEPTNO	DNAME
-----	-----	-----	-----
7369	SMITH	20	Research
7499	ALLEN	30	Sales
7521	WARD	30	Sales
7566	JONES	20	Research
7654	MARTIN	30	Sales
7698	BLAKE	30	Sales
7782	CLARK	10	Accounting
7788	SCOTT	20	Research
7839	KING	10	Accounting
7844	TURNER	30	Sales
7876	ADAMS	20	Research
7900	JAMES	30	Sales
7902	FORD	20	Research
7934	MILLER	10	Accounting

3.5.5 CASE Statement

The `CASE` statement executes a set of one or more statements when a specified search condition is `TRUE`. The `CASE` statement is a stand-alone statement in itself while the previously discussed `CASE` expression must appear as part of an expression.

There are two formats of the `CASE` statement - one that is called a *searched CASE* and the other that uses a *selector*.

3.5.5.1 Selector CASE Statement

The selector `CASE` statement attempts to match an expression called the selector to the expression specified in one or more `WHEN` clauses. When a match is found one or more corresponding statements are executed.

```
CASE selector-expression
  WHEN match-expression THEN
    statements
  [ WHEN match-expression THEN
    statements
  [ WHEN match-expression THEN
    statements ] ... ]
  [ ELSE
    statements ]
END CASE;
```

`selector-expression` returns a value type-compatible with each `match-expression`. `match-expression` is evaluated in the order in which it appears within the `CASE` statement. `statements` are one or more SPL statements, each terminated by a semi-colon. When the value of `selector-expression` equals the first `match-expression`, the statement(s) in the corresponding `THEN` clause are executed and control continues following the `END CASE` keywords. If there are no matches, the statement(s) following `ELSE` are executed. If there are no matches and there is no `ELSE` clause, an exception is thrown.

The following example uses a selector `CASE` statement to assign a department name and location to a variable based upon the department number.

```
DECLARE
  v_empno      emp.empno%TYPE;
  v_ename      emp.ename%TYPE;
  v_deptno     emp.deptno%TYPE;
  v_dname      dept.dname%TYPE;
  v_loc        dept.loc%TYPE;
  CURSOR emp_cursor IS SELECT empno, ename, deptno FROM emp;
BEGIN
```

```

OPEN emp_cursor;
DBMS_OUTPUT.PUT_LINE('EMPNO      ENAME      DEPTNO      DNAME      ');
DBMS_OUTPUT.PUT_LINE('----      -----      -----      -----');
DBMS_OUTPUT.PUT_LINE('||      -----');
LOOP
  FETCH emp_cursor INTO v_empno, v_ename, v_deptno;
  EXIT WHEN emp_cursor%NOTFOUND;
  CASE v_deptno
    WHEN 10 THEN v_dname := 'Accounting';
                v_loc   := 'New York';
    WHEN 20 THEN v_dname := 'Research';
                v_loc   := 'Dallas';
    WHEN 30 THEN v_dname := 'Sales';
                v_loc   := 'Chicago';
    WHEN 40 THEN v_dname := 'Operations';
                v_loc   := 'Boston';
    ELSE v_dname := 'unknown';
                v_loc   := '';
  END CASE;
  DBMS_OUTPUT.PUT_LINE(v_empno || '      ' || RPAD(v_ename, 10) ||
                       ' || v_deptno || '      ' || RPAD(v_dname, 14) || ' ' ||
                       v_loc);
END LOOP;
CLOSE emp_cursor;
END;

```

The following is the output from this program.

EMPNO	ENAME	DEPTNO	DNAME	LOC
7369	SMITH	20	Research	Dallas
7499	ALLEN	30	Sales	Chicago
7521	WARD	30	Sales	Chicago
7566	JONES	20	Research	Dallas
7654	MARTIN	30	Sales	Chicago
7698	BLAKE	30	Sales	Chicago
7782	CLARK	10	Accounting	New York
7788	SCOTT	20	Research	Dallas
7839	KING	10	Accounting	New York
7844	TURNER	30	Sales	Chicago
7876	ADAMS	20	Research	Dallas
7900	JAMES	30	Sales	Chicago
7902	FORD	20	Research	Dallas
7934	MILLER	10	Accounting	New York

3.5.5.2 Searched CASE statement

A searched CASE statement uses one or more Boolean expressions to determine the resulting set of statements to execute.

```

CASE WHEN boolean-expression THEN
      statements
[ WHEN boolean-expression THEN
      statements
[ WHEN boolean-expression THEN
      statements ] ... ]
[ ELSE
      statements ]

```

```

statements ]
END CASE;
```

boolean-expression is evaluated in the order in which it appears within the `CASE` statement. When the first *boolean-expression* is encountered that evaluates to `TRUE`, the statement(s) in the corresponding `THEN` clause are executed and control continues following the `END CASE` keywords. If none of *boolean-expression* evaluates to `TRUE`, the statement(s) following `ELSE` are executed. If none of *boolean-expression* evaluates to `TRUE` and there is no `ELSE` clause, an exception is thrown.

The following example uses a searched `CASE` statement to assign a department name and location to a variable based upon the department number.

```

DECLARE
    v_empno      emp.empno%TYPE;
    v_ename       emp.ename%TYPE;
    v_deptno     emp.deptno%TYPE;
    v_dname       dept.dname%TYPE;
    v_loc         dept.loc%TYPE;
    CURSOR emp_cursor IS SELECT empno, ename, deptno FROM emp;
BEGIN
    OPEN emp_cursor;
    DBMS_OUTPUT.PUT_LINE('EMPNO      ENAME      DEPTNO      DNAME      ');
    DBMS_OUTPUT.PUT_LINE('|| '        'LOC'||');
    DBMS_OUTPUT.PUT_LINE('-----  -----  -----  -----  -----');
    DBMS_OUTPUT.PUT_LINE('|| '        '-----'||');
    LOOP
        FETCH emp_cursor INTO v_empno, v_ename, v_deptno;
        EXIT WHEN emp_cursor%NOTFOUND;
        CASE
            WHEN v_deptno = 10 THEN v_dname := 'Accounting';
                v_loc   := 'New York';
            WHEN v_deptno = 20 THEN v_dname := 'Research';
                v_loc   := 'Dallas';
            WHEN v_deptno = 30 THEN v_dname := 'Sales';
                v_loc   := 'Chicago';
            WHEN v_deptno = 40 THEN v_dname := 'Operations';
                v_loc   := 'Boston';
            ELSE v_dname := 'unknown';
                v_loc   := '';
        END CASE;
        DBMS_OUTPUT.PUT_LINE(v_empno || '      ' || RPAD(v_ename, 10) ||
                            ' ' || v_deptno || '      ' || RPAD(v_dname, 14) || ' ' ||
                            v_loc);
    END LOOP;
    CLOSE emp_cursor;
END;
```

The following is the output from this program.

EMPNO	ENAME	DEPTNO	DNAME	LOC
7369	SMITH	20	Research	Dallas
7499	ALLEN	30	Sales	Chicago
7521	WARD	30	Sales	Chicago
7566	JONES	20	Research	Dallas
7654	MARTIN	30	Sales	Chicago

Database Compatibility for Oracle® Developers Guide

7698	BLAKE	30	Sales	Chicago
7782	CLARK	10	Accounting	New York
7788	SCOTT	20	Research	Dallas
7839	KING	10	Accounting	New York
7844	TURNER	30	Sales	Chicago
7876	ADAMS	20	Research	Dallas
7900	JAMES	30	Sales	Chicago
7902	FORD	20	Research	Dallas
7934	MILLER	10	Accounting	New York

3.5.6 Loops

With the `LOOP`, `EXIT`, `CONTINUE`, `WHILE`, and `FOR` statements, you can arrange for your SPL program to repeat a series of commands.

3.5.6.1 LOOP

```
LOOP
    statements
END LOOP;
```

`LOOP` defines an unconditional loop that is repeated indefinitely until terminated by an `EXIT` or `RETURN` statement.

3.5.6.2 EXIT

```
EXIT [ WHEN expression ];
```

The innermost loop is terminated and the statement following `END LOOP` is executed next.

If `WHEN` is present, loop exit occurs only if the specified condition is `TRUE`, otherwise control passes to the statement after `EXIT`.

`EXIT` can be used to cause early exit from all types of loops; it is not limited to use with unconditional loops.

The following is a simple example of a loop that iterates ten times and then uses the `EXIT` statement to terminate.

```
DECLARE
    v_counter      NUMBER (2);
BEGIN
    v_counter := 1;
    LOOP
        EXIT WHEN v_counter > 10;
        DBMS_OUTPUT.PUT_LINE('Iteration #' || v_counter);
        v_counter := v_counter + 1;
    END LOOP;
END;
```

The following is the output from this program.

```
Iteration # 1
Iteration # 2
Iteration # 3
Iteration # 4
Iteration # 5
Iteration # 6
Iteration # 7
```

```
Iteration # 8
Iteration # 9
Iteration # 10
```

3.5.6.3 CONTINUE

The `CONTINUE` statement provides a way to proceed with the next iteration of a loop while skipping intervening statements.

When the `CONTINUE` statement is encountered, the next iteration of the innermost loop is begun, skipping all statements following the `CONTINUE` statement until the end of the loop. That is, control is passed back to the loop control expression, if any, and the body of the loop is re-evaluated.

If the `WHEN` clause is used, then the next iteration of the loop is begun only if the specified expression in the `WHEN` clause evaluates to `TRUE`. Otherwise, control is passed to the next statement following the `CONTINUE` statement.

The `CONTINUE` statement may not be used outside of a loop.

The following is a variation of the previous example that uses the `CONTINUE` statement to skip the display of the odd numbers.

```
DECLARE
    v_counter      NUMBER(2);
BEGIN
    v_counter := 0;
    LOOP
        v_counter := v_counter + 1;
        EXIT WHEN v_counter > 10;
        CONTINUE WHEN MOD(v_counter,2) = 1;
        DBMS_OUTPUT.PUT_LINE('Iteration #' || v_counter);
    END LOOP;
END;
```

The following is the output from above program.

```
Iteration # 2
Iteration # 4
Iteration # 6
Iteration # 8
Iteration # 10
```

3.5.6.4 WHILE

```
WHILE expression LOOP
    statements
END LOOP;
```

The `WHILE` statement repeats a sequence of statements so long as the condition expression evaluates to `TRUE`. The condition is checked just before each entry to the loop body.

The following example contains the same logic as in the previous example except the WHILE statement is used to take the place of the EXIT statement to determine when to exit the loop.

Note: The conditional expression used to determine when to exit the loop must be altered. The EXIT statement terminates the loop when its conditional expression is true. The WHILE statement terminates (or never begins the loop) when its conditional expression is false.

```
DECLARE
    v_counter      NUMBER (2);
BEGIN
    v_counter := 1;
    WHILE v_counter <= 10 LOOP
        DBMS_OUTPUT.PUT_LINE('Iteration # ' || v_counter);
        v_counter := v_counter + 1;
    END LOOP;
END;
```

The same result is generated by this example as in the prior example.

```
Iteration # 1
Iteration # 2
Iteration # 3
Iteration # 4
Iteration # 5
Iteration # 6
Iteration # 7
Iteration # 8
Iteration # 9
Iteration # 10
```

3.5.6.5 FOR (integer variant)

```
FOR name IN [REVERSE] expression .. expression LOOP
    statements
END LOOP;
```

This form of FOR creates a loop that iterates over a range of integer values. The variable *name* is automatically defined as type INTEGER and exists only inside the loop. The two expressions giving the loop range are evaluated once when entering the loop. The iteration step is +1 and *name* begins with the value of *expression* to the left of .. and terminates once *name* exceeds the value of *expression* to the right of .. Thus the two expressions take on the following roles: *start-value..end-value*.

The optional REVERSE clause specifies that the loop should iterate in reverse order. The first time through the loop, *name* is set to the value of the right-most *expression*; the loop terminates when the *name* is less than the left-most *expression*.

The following example simplifies the WHILE loop example even further by using a FOR loop that iterates from 1 to 10.

```
BEGIN
    FOR i IN 1 .. 10 LOOP
        DBMS_OUTPUT.PUT_LINE('Iteration # ' || i);
    END LOOP;
END;
```

Here is the output using the FOR statement.

```
Iteration # 1
Iteration # 2
Iteration # 3
Iteration # 4
Iteration # 5
Iteration # 6
Iteration # 7
Iteration # 8
Iteration # 9
Iteration # 10
```

If the start value is greater than the end value the loop body is not executed at all. No error is raised as shown by the following example.

```
BEGIN
    FOR i IN 10 .. 1 LOOP
        DBMS_OUTPUT.PUT_LINE('Iteration # ' || i);
    END LOOP;
END;
```

There is no output from this example as the loop body is never executed.

Note: SPL also supports CURSOR FOR loops (see Section [3.8.7](#)).

3.5.7 Exception Handling

By default, any error occurring in an SPL program aborts execution of the program. You can trap errors and recover from them by using a `BEGIN` block with an `EXCEPTION` section. The syntax is an extension of the normal syntax for a `BEGIN` block:

```
[ DECLARE
    declarations ]
BEGIN
    statements
EXCEPTION
    WHEN condition [ OR condition ]... THEN
        handler_statements
    [ WHEN condition [ OR condition ]... THEN
        handler_statements ]...
END;
```

If no error occurs, this form of block simply executes all the `statements`, and then control passes to the next statement after `END`. If an error occurs within the `statements`, further processing of the `statements` is abandoned, and control passes to the `EXCEPTION` list. The list is searched for the first `condition` matching the error that occurred. If a match is found, the corresponding `handler_statements` are executed, and then control passes to the next statement after `END`. If no match is found, the error propagates out as though the `EXCEPTION` clause were not there at all. The error can be caught by an enclosing block with `EXCEPTION`; if there is no enclosing block, it aborts processing of the subprogram.

The special condition name `OTHERS` matches every error type. Condition names are not case-sensitive.

If a new error occurs within the selected `handler_statements`, it cannot be caught by this `EXCEPTION` clause, but is propagated out. A surrounding `EXCEPTION` clause could catch it.

The following table lists the condition names that may be used:

Table 3-2 Exception Condition Names

Condition Name	Description
<code>CASE_NOT_FOUND</code>	The application has encountered a situation where none of the cases in a <code>CASE</code> statement evaluates to <code>TRUE</code> and there is no <code>ELSE</code> condition.
<code>COLLECTION_IS_NULL</code>	The application has attempted to invoke a collection method on a null collection such as an uninitialized nested table.
<code>CURSOR_ALREADY_OPEN</code>	The application has attempted to open a cursor that is already open.

Condition Name	Description
DUP_VAL_ON_INDEX	The application has attempted to store a duplicate value that currently exists within a constrained column.
INVALID_CURSOR	The application has attempted to access an unopened cursor.
INVALID_NUMBER	The application has encountered a data exception (equivalent to SQLSTATE class code 22). <code>INVALID_NUMBER</code> is an alias for <code>VALUE_ERROR</code> .
NO_DATA_FOUND	No rows satisfy the selection criteria.
OTHERS	The application has encountered an exception that hasn't been caught by a prior condition in the exception section.
SUBSCRIPT_BEYOND_COUNT	The application has attempted to reference a subscript of a nested table or varray beyond its initialized or extended size.
SUBSCRIPT_OUTSIDE_LIMIT	The application has attempted to reference a subscript or extend a varray beyond its maximum size limit.
TOO_MANY_ROWS	The application has encountered more than one row that satisfies the selection criteria (where only one row is allowed to be returned).
VALUE_ERROR	The application has encountered a data exception (equivalent to SQLSTATE class code 22). <code>VALUE_ERROR</code> is an alias for <code>INVALID_NUMBER</code> .
ZERO_DIVIDE	The application has tried to divide by zero.
<i>User-defined Exception</i>	See Section 3.5.8

Note: Condition names `INVALID_NUMBER` and `VALUE_ERROR` are not compatible with Oracle databases for which these condition names are for exceptions resulting only from a failed conversion of a string to a numeric literal. In addition, for Oracle databases, an `INVALID_NUMBER` exception is applicable only to SQL statements while a `VALUE_ERROR` exception is applicable only to procedural statements.

3.5.8 User-defined Exceptions

Any number of errors (referred to in PL/SQL as *exceptions*) can occur during program execution. When an exception is *thrown*, normal execution of the program stops, and control of the program transfers to the error-handling portion of the program. An *exception* may be a pre-defined error that is generated by the server, or may be a logical error that raises a user-defined exception.

User-defined exceptions are never raised by the server; they are raised explicitly by a `RAISE` statement. A user-defined exception is raised when a developer-defined logical rule is broken; a common example of a logical rule being broken occurs when a check is presented against an account with insufficient funds. An attempt to cash a check against an account with insufficient funds will provoke a user-defined exception.

You can define exceptions in functions, procedures, packages or anonymous blocks. While you cannot declare the same exception twice in the same block, you can declare the same exception in two different blocks.

Before implementing a user-defined exception, you must declare the exception in the declaration section of a function, procedure, package or anonymous block. You can then raise the exception using the `RAISE` statement:

```
DECLARE
    exception_name EXCEPTION;

BEGIN
    ...
    RAISE exception_name;
    ...
END;
```

`exception_name` is the name of the exception.

Unhandled exceptions propagate back through the call stack. If the exception remains unhandled, the exception is eventually reported to the client application.

User-defined exceptions declared in a block are considered to be local to that block, and global to any nested blocks within the block. To reference an exception that resides in an outer block, you must assign a label to the outer block; then, preface the name of the exception with the block name:

`block_name.exception_name`

Conversely, outer blocks cannot reference exceptions declared in nested blocks.

The scope of a declaration is limited to the block in which it is declared *unless* it is created in a package, and when referenced, qualified by the package name. For example, to raise an exception named `out_of_stock` that resides in a package named `inventory_control` a program must raise an error named:

```
inventory_control.out_of_stock
```

The following example demonstrates declaring a user-defined exception in a package. The user-defined exception does not require a package-qualifier when it is raised in `check_balance`, since it resides in the same package as the exception:

```
CREATE OR REPLACE PACKAGE ar AS
    overdrawn EXCEPTION;
    PROCEDURE check_balance(p_balance NUMBER, p_amount NUMBER);
END;

CREATE OR REPLACE PACKAGE BODY ar AS
    PROCEDURE check_balance(p_balance NUMBER, p_amount NUMBER)
    IS
    BEGIN
        IF (p_amount > p_balance) THEN
            RAISE overdrawn;
        END IF;
    END;
```

The following procedure (`purchase`) calls the `check_balance` procedure. If `p_amount` is greater than `p_balance`, `check_balance` raises an exception; `purchase` catches the `ar.overdrawn` exception. `purchase` must refer to the exception with a package-qualified name (`ar.overdrawn`) because `purchase` is not defined within the `ar` package.

```
CREATE PROCEDURE purchase(customerID INT, amount NUMERIC)
AS
BEGIN
    ar.check_balance(getcustomerbalance(customerid), amount);
    record_purchase(customerid, amount);
EXCEPTION
    WHEN ar.overdrawn THEN
        raise_credit_limit(customerid, amount*1.5);
END;
```

When `ar.check_balance` raises an exception, execution jumps to the exception handler defined in `purchase`:

```
EXCEPTION
    WHEN ar.overdrawn THEN
        raise_credit_limit(customerid, amount*1.5);
```

The exception handler raises the customer's credit limit and ends. When the exception handler ends, execution resumes with the statement that follows `ar.check_balance`.

3.5.9 PRAGMA EXCEPTION_INIT

PRAGMA EXCEPTION_INIT associates a user-defined error code with an exception. A PRAGMA EXCEPTION_INIT declaration may be included in any block, sub-block or package. You can only assign an error code to an exception (using PRAGMA EXCEPTION_INIT) after declaring the exception. The format of a PRAGMA EXCEPTION_INIT declaration is:

```
PRAGMA EXCEPTION_INIT(exception_name,
                      {exception_number | exception_code})
```

Where:

exception_name is the name of the associated exception.

exception_number is a user-defined error code associated with the pragma. If you specify an unmapped *exception_number*, the server will return a warning.

exception_code is the name of a pre-defined exception. For a complete list of valid exceptions, see the Postgres core documentation available at:

<https://www.postgresql.org/docs/10/static/errcodes-appendix.html>

The previous section (*User-defined Exceptions*) included an example that demonstrates declaring a user-defined exception in a package. The following example uses the same basic structure, but adds a PRAGMA EXCEPTION_INIT declaration:

```
CREATE OR REPLACE PACKAGE ar AS
    overdrawn EXCEPTION;
    PRAGMA EXCEPTION_INIT (overdrawn, -20100);
    PROCEDURE check_balance(p_balance NUMBER, p_amount NUMBER);
END;

CREATE OR REPLACE PACKAGE BODY ar AS
    PROCEDURE check_balance(p_balance NUMBER, p_amount NUMBER)
    IS
    BEGIN
        IF (p_amount > p_balance) THEN
            RAISE overdrawn;
        END IF;
    END;
```

The following procedure (*purchase*) calls the *check_balance* procedure. If *p_amount* is greater than *p_balance*, *check_balance* raises an exception; *purchase* catches the *ar.overdrawn* exception.

```

CREATE PROCEDURE purchase(customerID int, amount NUMERIC)
AS
BEGIN
    ar.check_balance(getcustomerbalance(customerid), amount);
    record_purchase(customerid, amount);
EXCEPTION
    WHEN ar.overdrawn THEN
        DBMS_OUTPUT.PUT_LINE ('This account is overdrawn.');
        DBMS_OUTPUT.PUT_LINE ('SQLCode :'||SQLCODE||' '||SQLERRM );
END;

```

When `ar.check_balance` raises an exception, execution jumps to the exception handler defined in `purchase`.

```

EXCEPTION
    WHEN ar.overdrawn THEN
        DBMS_OUTPUT.PUT_LINE ('This account is overdrawn.');
        DBMS_OUTPUT.PUT_LINE ('SQLCode :'||SQLCODE||' '||SQLERRM );

```

The exception handler returns an error message, followed by `SQLCODE` information:

```

This account is overdrawn.
SQLCODE: -20100 User-Defined Exception

```

The following example demonstrates using a pre-defined exception. The code creates a more meaningful name for the `no_data_found` exception; if the given customer does not exist, the code catches the exception, calls `DBMS_OUTPUT.PUT_LINE` to report the error, and then re-raises the original exception:

```

CREATE OR REPLACE PACKAGE ar AS
    overdrawn EXCEPTION;
    PRAGMA EXCEPTION_INIT (unknown_customer, no_data_found);
    PROCEDURE check_balance(p_customer_id NUMBER);
END;

CREATE OR REPLACE PACKAGE BODY ar AS
    PROCEDURE check_balance(p_customer_id NUMBER)
    IS
    DECLARE
        v_balance NUMBER;
    BEGIN
        SELECT balance INTO v_balance FROM customer
        WHERE cust_id = p_customer_id;
    EXCEPTION WHEN unknown_customer THEN
        DBMS_OUTPUT.PUT_LINE('invalid customer id');
        RAISE;
    END;

```

3.5.10 RAISE_APPLICATION_ERROR

The procedure, RAISE_APPLICATION_ERROR, allows a developer to intentionally abort processing within an SPL program from which it is called by causing an exception. The exception is handled in the same manner as described in Section 3.5.7. In addition, the RAISE_APPLICATION_ERROR procedure makes a user-defined code and error message available to the program which can then be used to identify the exception.

```
RAISE_APPLICATION_ERROR(error_number, message);
```

Where:

error_number is an integer value or expression that is returned in a variable named SQLCODE when the procedure is executed. *error_number* must be a value between -20000 and -20999.

message is a string literal or expression that is returned in a variable named SQLERRM.

For additional information on the SQLCODE and SQLERRM variables, see Section 3.13, *Errors and Messages*.

The following example uses the RAISE_APPLICATION_ERROR procedure to display a different code and message depending upon the information missing from an employee.

```
CREATE OR REPLACE PROCEDURE verify_emp (
    p_empno          NUMBER
)
IS
    v_ename           emp.ename%TYPE;
    v_job             emp.job%TYPE;
    v_mgr             emp.mgr%TYPE;
    v_hiredate        emp.hiredate%TYPE;
BEGIN
    SELECT ename, job, mgr, hiredate
      INTO v_ename, v_job, v_mgr, v_hiredate
     FROM emp
    WHERE empno = p_empno;
    IF v_ename IS NULL THEN
        RAISE_APPLICATION_ERROR(-20010, 'No name for ' || p_empno);
    END IF;
    IF v_job IS NULL THEN
        RAISE_APPLICATION_ERROR(-20020, 'No job for' || p_empno);
    END IF;
    IF v_mgr IS NULL THEN
        RAISE_APPLICATION_ERROR(-20030, 'No manager for ' || p_empno);
    END IF;
    IF v_hiredate IS NULL THEN
        RAISE_APPLICATION_ERROR(-20040, 'No hire date for ' || p_empno);
    END IF;
    DBMS_OUTPUT.PUT_LINE('Employee ' || p_empno ||
        ' validated without errors');
EXCEPTION
```

```
WHEN OTHERS THEN
    DBMS_OUTPUT.PUT_LINE('SQLCODE: ' || SQLCODE);
    DBMS_OUTPUT.PUT_LINE('SQLERRM: ' || SQLERRM);
END;
```

The following shows the output in a case where the manager number is missing from an employee record.

```
EXEC verify_emp(7839);

SQLCODE: -20030
SQLERRM: EDB-20030: No manager for 7839
```

3.6 Transaction Control

There may be circumstances where it is desired that all updates to a database are to occur successfully, or none are to occur at all if any error occurs. A set of database updates that are to all occur successfully as a single unit, or are not to occur at all, is said to be a *transaction*.

A common example in banking is a funds transfer between two accounts. The two parts of the transaction are the withdrawal of funds from one account, and the deposit of the funds in another account. Both parts of this transaction must occur otherwise the bank's books will be out of balance. The deposit and withdrawal are one transaction.

An SPL application can be created that uses a style of transaction control compatible with Oracle databases if the following conditions are met:

- The `edb_stmt_level_tx` parameter must be set to `TRUE`. This prevents the action of unconditionally rolling back all database updates within the `BEGIN/END` block if any exception occurs. See Section [1.3.4](#) for more information on the `edb_stmt_level_tx` parameter.
- The application must not be running in autocommit mode. If autocommit mode is on, each successful database update is immediately committed and cannot be undone. The manner in which autocommit mode is turned on or off is application dependent.

A transaction begins when the first SQL command is encountered in the SPL program. All subsequent SQL commands are included as part of that transaction. The transaction ends when one of the following occurs:

- An unhandled exception occurs in which case the effects of all database updates made during the transaction are rolled back and the transaction is aborted.
- A `COMMIT` command is encountered in which case the effect of all database updates made during the transaction become permanent.
- A `ROLLBACK` command is encountered in which case the effects of all database updates made during the transaction are rolled back and the transaction is aborted. If a new SQL command is encountered, a new transaction begins.
- Control returns to the calling application (such as Java, PSQL, etc.) in which case the action of the application determines whether the transaction is committed or rolled back.

Note: Unlike Oracle, DDL commands such as `CREATE TABLE` do not implicitly occur within their own transaction. Therefore, DDL commands do not automatically cause an immediate database commit as in Oracle, and DDL commands may be rolled back just like DML commands.

A transaction may span one or more BEGIN/END blocks, or a single BEGIN/END block may contain one or more transactions.

The following sections discuss the COMMIT and ROLLBACK commands in more detail.

3.6.1 COMMIT

The COMMIT command makes all database updates made during the current transaction permanent, and ends the current transaction.

```
COMMIT [ WORK ];
```

The COMMIT command may be used within anonymous blocks, stored procedures, or functions. Within an SPL program, it may appear in the executable section and/or the exception section.

In the following example, the third INSERT command in the anonymous block results in an error. The effect of the first two INSERT commands are retained as shown by the first SELECT command. Even after issuing a ROLLBACK command, the two rows remain in the table as shown by the second SELECT command verifying that they were indeed committed.

Note: The `edb_stmt_level_tx` configuration parameter shown in the example below can be set for the entire database using the ALTER DATABASE command, or it can be set for the entire database server by changing it in the `postgresql.conf` file.

```
\set AUTOCOMMIT off
SET edb_stmt_level_tx TO on;

BEGIN
    INSERT INTO dept VALUES (50, 'FINANCE', 'DALLAS');
    INSERT INTO dept VALUES (60, 'MARKETING', 'CHICAGO');
    COMMIT;
    INSERT INTO dept VALUES (70, 'HUMAN RESOURCES', 'CHICAGO');
EXCEPTION
    WHEN OTHERS THEN
        DBMS_OUTPUT.PUT_LINE('SQLERRM: ' || SQLERRM);
        DBMS_OUTPUT.PUT_LINE('SQLCODE: ' || SQLCODE);
END;

SQLERRM: value too long for type character varying(14)
SQLCODE: 22001

SELECT * FROM dept;

deptno | dname      | loc
-----+-----+-----
  10 | ACCOUNTING | NEW YORK
  20 | RESEARCH   | DALLAS
  30 | SALES      | CHICAGO
```

```

40 | OPERATIONS | BOSTON
50 | FINANCE     | DALLAS
60 | MARKETING   | CHICAGO
(6 rows)

ROLLBACK;

SELECT * FROM dept;

deptno |    dname      |    loc
-----+-----+-----+
 10 | ACCOUNTING  | NEW YORK
 20 | RESEARCH    | DALLAS
 30 | SALES       | CHICAGO
 40 | OPERATIONS  | BOSTON
 50 | FINANCE     | DALLAS
 60 | MARKETING   | CHICAGO
(6 rows)

```

3.6.2 ROLLBACK

The `ROLLBACK` command undoes all database updates made during the current transaction, and ends the current transaction.

```
ROLLBACK [ WORK ];
```

The `ROLLBACK` command may be used within anonymous blocks, stored procedures, or functions. Within an SPL program, it may appear in the executable section and/or the exception section.

In the following example, the exception section contains a `ROLLBACK` command. Even though the first two `INSERT` commands are executed successfully, the third results in an exception that results in the rollback of all the `INSERT` commands in the anonymous block.

```

\set AUTOCOMMIT off
SET edb_stmt_level_tx TO on;

BEGIN
    INSERT INTO dept VALUES (50, 'FINANCE', 'DALLAS');
    INSERT INTO dept VALUES (60, 'MARKETING', 'CHICAGO');
    INSERT INTO dept VALUES (70, 'HUMAN RESOURCES', 'CHICAGO');
EXCEPTION
    WHEN OTHERS THEN
        ROLLBACK;
        DBMS_OUTPUT.PUT_LINE('SQLERRM: ' || SQLERRM);
        DBMS_OUTPUT.PUT_LINE('SQLCODE: ' || SQLCODE);
END;

SQLERRM: value too long for type character varying(14)
SQLCODE: 22001

SELECT * FROM dept;

deptno |    dname      |    loc
-----+-----+-----+
 10 | ACCOUNTING  | NEW YORK
 20 | RESEARCH    | DALLAS
 30 | SALES       | CHICAGO
 40 | OPERATIONS  | BOSTON
 50 | FINANCE     | DALLAS
 60 | MARKETING   | CHICAGO
(6 rows)

```

```
-----+-----+-----+
 10 | ACCOUNTING | NEW YORK
 20 | RESEARCH   | DALLAS
 30 | SALES      | CHICAGO
 40 | OPERATIONS | BOSTON
(4 rows)
```

The following is a more complex example using both COMMIT and ROLLBACK. First, the following stored procedure is created which inserts a new employee.

```
\set AUTOCOMMIT off
SET edb_stmt_level_tx TO on;

CREATE OR REPLACE PROCEDURE emp_insert (
    p_empno          IN emp.empno%TYPE,
    p_ename           IN emp.ename%TYPE,
    p_job             IN emp.job%TYPE,
    p_mgr             IN emp.mgr%TYPE,
    p_hiredate       IN emp.hiredate%TYPE,
    p_sal             IN emp.sal%TYPE,
    p_comm            IN emp.comm%TYPE,
    p_deptno          IN emp.deptno%TYPE
)
IS
BEGIN
    INSERT INTO emp VALUES (
        p_empno,
        p_ename,
        p_job,
        p_mgr,
        p_hiredate,
        p_sal,
        p_comm,
        p_deptno);

    DBMS_OUTPUT.PUT_LINE('Added employee...');
    DBMS_OUTPUT.PUT_LINE('Employee # : ' || p_empno);
    DBMS_OUTPUT.PUT_LINE('Name      : ' || p_ename);
    DBMS_OUTPUT.PUT_LINE('Job       : ' || p_job);
    DBMS_OUTPUT.PUT_LINE('Manager   : ' || p_mgr);
    DBMS_OUTPUT.PUT_LINE('Hire Date : ' || p_hiredate);
    DBMS_OUTPUT.PUT_LINE('Salary    : ' || p_sal);
    DBMS_OUTPUT.PUT_LINE('Commission: ' || p_comm);
    DBMS_OUTPUT.PUT_LINE('Dept #   : ' || p_deptno);
    DBMS_OUTPUT.PUT_LINE('-----');
END;
```

Note that this procedure has no exception section so any error that may occur is propagated up to the calling program.

The following anonymous block is run. Note the use of the COMMIT command after all calls to the emp_insert procedure and the ROLLBACK command in the exception section.

```
BEGIN
    emp_insert(9601, 'FARRELL', 'ANALYST', 7902, '03-MAR-08', 5000, NULL, 40);
    emp_insert(9602, 'TYLER', 'ANALYST', 7900, '25-JAN-08', 4800, NULL, 40);
    COMMIT;
EXCEPTION
```

```

WHEN OTHERS THEN
    DBMS_OUTPUT.PUT_LINE('SQLERRM: ' || SQLERRM);
    DBMS_OUTPUT.PUT_LINE('An error occurred - roll back inserts');
    ROLLBACK;
END;

Added employee...
Employee # : 9601
Name      : FARRELL
Job       : ANALYST
Manager   : 7902
Hire Date : 03-MAR-08 00:00:00
Salary    : 5000
Commission :
Dept #   : 40
-----
Added employee...
Employee # : 9602
Name      : TYLER
Job       : ANALYST
Manager   : 7900
Hire Date : 25-JAN-08 00:00:00
Salary    : 4800
Commission :
Dept #   : 40
-----
```

The following SELECT command shows that employees Farrell and Tyler were successfully added.

```

SELECT * FROM emp WHERE empno > 9600;

empno | ename | job | mgr | hiredate | sal | comm | deptno
-----+-----+-----+-----+-----+-----+-----+-----+
9601 | FARRELL | ANALYST | 7902 | 03-MAR-08 00:00:00 | 5000.00 | | 40
9602 | TYLER | ANALYST | 7900 | 25-JAN-08 00:00:00 | 4800.00 | | 40
(2 rows)
```

Now, execute the following anonymous block:

```

BEGIN
    emp_insert(9603, 'HARRISON', 'SALESMAN', 7902, '13-DEC-07', 5000, 3000, 20);
    emp_insert(9604, 'JARVIS', 'SALESMAN', 7902, '05-MAY-08', 4800, 4100, 11);
    COMMIT;
EXCEPTION
    WHEN OTHERS THEN
        DBMS_OUTPUT.PUT_LINE('SQLERRM: ' || SQLERRM);
        DBMS_OUTPUT.PUT_LINE('An error occurred - roll back inserts');
        ROLLBACK;
END;

Added employee...
Employee # : 9603
Name      : HARRISON
Job       : SALESMAN
Manager   : 7902
Hire Date : 13-DEC-07 00:00:00
Salary    : 5000
Commission : 3000
Dept #   : 20
-----
```

```
SQLERRM: insert or update on table "emp" violates foreign key constraint  
"emp_ref_dept_fk"  
An error occurred - roll back inserts
```

A SELECT command run against the table yields the following:

```
SELECT * FROM emp WHERE empno > 9600;
```

empno	ename	job	mgr	hiredate	sal	comm	deptno
9601	FARRELL	ANALYST	7902	03-MAR-08 00:00:00	5000.00		40
9602	TYLER	ANALYST	7900	25-JAN-08 00:00:00	4800.00		40

(2 rows)

The ROLLBACK command in the exception section successfully undoes the insert of employee Harrison. Also note that employees Farrell and Tyler are still in the table as their inserts were made permanent by the COMMIT command in the first anonymous block.

3.7 Dynamic SQL

Dynamic SQL is a technique that provides the ability to execute SQL commands that are not known until the commands are about to be executed. Up to this point, the SQL commands that have been illustrated in SPL programs have been static SQL - the full command (with the exception of variables) must be known and coded into the program before the program, itself, can begin to execute. Thus using dynamic SQL, the executed SQL can change during program runtime.

In addition, dynamic SQL is the only method by which data definition commands, such as `CREATE TABLE`, can be executed from within an SPL program.

Note, however, that the runtime performance of dynamic SQL will be slower than static SQL.

The `EXECUTE IMMEDIATE` command is used to run SQL commands dynamically.

```
EXECUTE IMMEDIATE 'sql_expression;
[ INTO { variable [, ...] | record } ]
[ USING expression [, ...] ]'
```

sql_expression is a string expression containing the SQL command to be dynamically executed. *variable* receives the output of the result set, typically from a `SELECT` command, created as a result of executing the SQL command in *sql_expression*. The number, order, and type of variables must match the number, order, and be type-compatible with the fields of the result set. Alternatively, a record can be specified as long as the record's fields match the number, order, and are type-compatible with the result set. When using the `INTO` clause, exactly one row must be returned in the result set, otherwise an exception occurs. When using the `USING` clause the value of *expression* is passed to a *placeholder*. Placeholders appear embedded within the SQL command in *sql_expression* where variables may be used.

Placeholders are denoted by an identifier with a colon (:) prefix - `:name`. The number, order, and resultant data types of the evaluated expressions must match the number, order and be type-compatible with the placeholders in *sql_expression*. Note that placeholders are not declared anywhere in the SPL program – they only appear in *sql_expression*.

The following example shows basic dynamic SQL commands as string literals.

```
DECLARE
    v_sql          VARCHAR2(50);
BEGIN
    EXECUTE IMMEDIATE 'CREATE TABLE job (jobno NUMBER(3), ' ||
```

```

        ' jname VARCHAR2(9))';
v_sql := 'INSERT INTO job VALUES (100, ''ANALYST'')';
EXECUTE IMMEDIATE v_sql;
v_sql := 'INSERT INTO job VALUES (200, ''CLERK'')';
EXECUTE IMMEDIATE v_sql;
END;

```

The following example illustrates the `USING` clause to pass values to placeholders in the SQL string.

```

DECLARE
    v_sql          VARCHAR2(50) := 'INSERT INTO job VALUES ' ||
                                '(:p_jobno, :p_jname)';
    v_jobno        job.jobno%TYPE;
    v_jname        job.jname%TYPE;
BEGIN
    v_jobno := 300;
    v_jname := 'MANAGER';
    EXECUTE IMMEDIATE v_sql USING v_jobno, v_jname;
    v_jobno := 400;
    v_jname := 'SALESMAN';
    EXECUTE IMMEDIATE v_sql USING v_jobno, v_jname;
    v_jobno := 500;
    v_jname := 'PRESIDENT';
    EXECUTE IMMEDIATE v_sql USING v_jobno, v_jname;
END;

```

The following example shows both the `INTO` and `USING` clauses. Note the last execution of the `SELECT` command returns the results into a record instead of individual variables.

```

DECLARE
    v_sql          VARCHAR2(60);
    v_jobno        job.jobno%TYPE;
    v_jname        job.jname%TYPE;
    r_job          job%ROWTYPE;
BEGIN
    DBMS_OUTPUT.PUT_LINE('JOBNO      JNAME');
    DBMS_OUTPUT.PUT_LINE('-----  -----');
    v_sql := 'SELECT jobno, jname FROM job WHERE jobno = :p_jobno';
    EXECUTE IMMEDIATE v_sql INTO v_jobno, v_jname USING 100;
    DBMS_OUTPUT.PUT_LINE(v_jobno || '      ' || v_jname);
    EXECUTE IMMEDIATE v_sql INTO v_jobno, v_jname USING 200;
    DBMS_OUTPUT.PUT_LINE(v_jobno || '      ' || v_jname);
    EXECUTE IMMEDIATE v_sql INTO v_jobno, v_jname USING 300;
    DBMS_OUTPUT.PUT_LINE(v_jobno || '      ' || v_jname);
    EXECUTE IMMEDIATE v_sql INTO v_jobno, v_jname USING 400;
    DBMS_OUTPUT.PUT_LINE(v_jobno || '      ' || v_jname);
    EXECUTE IMMEDIATE v_sql INTO r_job USING 500;
    DBMS_OUTPUT.PUT_LINE(r_job.jobno || '      ' || r_job.jname);
END;

```

The following is the output from the previous anonymous block:

JOBNO	JNAME
-----	-----
100	ANALYST
200	CLERK
300	MANAGER
400	SALESMAN

You can use the `BULK COLLECT` clause to assemble the result set from an `EXECUTE IMMEDIATE` statement into a named collection. See Section [3.12.4, EXECUTE IMMEDIATE BULK COLLECT](#) for information about using the `BULK COLLECT` clause.

3.8 Static Cursors

Rather than executing a whole query at once, it is possible to set up a *cursor* that encapsulates the query, and then read the query result set one row at a time. This allows the creation of SPL program logic that retrieves a row from the result set, does some processing on the data in that row, and then retrieves the next row and repeats the process.

Cursors are most often used in the context of a `FOR` or `WHILE` loop. A conditional test should be included in the SPL logic that detects when the end of the result set has been reached so the program can exit the loop.

3.8.1 Declaring a Cursor

In order to use a cursor, it must first be declared in the declaration section of the SPL program. A cursor declaration appears as follows:

```
CURSOR name IS query;
```

name is an identifier that will be used to reference the cursor and its result set later in the program. *query* is a SQL `SELECT` command that determines the result set retrievable by the cursor.

Note: An extension of this syntax allows the use of parameters. This is discussed in more detail in Section [3.8.8](#).

The following are some examples of cursor declarations:

```
CREATE OR REPLACE PROCEDURE cursor_example
IS
    CURSOR emp_cur_1 IS SELECT * FROM emp;
    CURSOR emp_cur_2 IS SELECT empno, ename FROM emp;
    CURSOR emp_cur_3 IS SELECT empno, ename FROM emp WHERE deptno = 10
        ORDER BY empno;
BEGIN
    ...
END;
```

3.8.2 Opening a Cursor

Before a cursor can be used to retrieve rows, it must first be opened. This is accomplished with the `OPEN` statement.

```
OPEN name;
```

name is the identifier of a cursor that has been previously declared in the declaration section of the SPL program. The `OPEN` statement must not be executed on a cursor that has already been, and still is open.

The following shows an OPEN statement with its corresponding cursor declaration.

```
CREATE OR REPLACE PROCEDURE cursor_example
IS
    CURSOR emp_cur_3 IS SELECT empno, ename FROM emp WHERE deptno = 10
        ORDER BY empno;
BEGIN
    OPEN emp_cur_3;
    ...
END;
```

3.8.3 Fetching Rows From a Cursor

Once a cursor has been opened, rows can be retrieved from the cursor's result set by using the `FETCH` statement.

```
FETCH name INTO { record | variable [, variable_2 ]... };
```

`name` is the identifier of a previously opened cursor. `record` is the identifier of a previously defined record (for example, using `table%ROWTYPE`). `variable`, `variable_2...` are SPL variables that will receive the field data from the fetched row. The fields in `record` or `variable`, `variable_2...` must match in number and order, the fields returned in the `SELECT` list of the query given in the cursor declaration. The data types of the fields in the `SELECT` list must match, or be implicitly convertible to the data types of the fields in `record` or the data types of `variable`, `variable_2...`

Note: There is a variation of `FETCH INTO` using the `BULK COLLECT` clause that can return multiple rows at a time into a collection. See Section [3.12.4](#) for more information on using the `BULK COLLECT` clause with the `FETCH INTO` statement.

The following shows the `FETCH` statement.

```
CREATE OR REPLACE PROCEDURE cursor_example
IS
    v_empno      NUMBER(4);
    v_ename      VARCHAR2(10);
    CURSOR emp_cur_3 IS SELECT empno, ename FROM emp WHERE deptno = 10
        ORDER BY empno;
BEGIN
    OPEN emp_cur_3;
    FETCH emp_cur_3 INTO v_empno, v_ename;
    ...
END;
```

Instead of explicitly declaring the data type of a target variable, `%TYPE` can be used instead. In this way, if the data type of the database column is changed, the target variable declaration in the SPL program does not have to be changed. `%TYPE` will automatically pick up the new data type of the specified column.

```
CREATE OR REPLACE PROCEDURE cursor_example
IS
    v_empno      emp.empno%TYPE;
```

```

v_ename          emp.ename%TYPE;
CURSOR emp_cur_3 IS SELECT empno, ename FROM emp WHERE deptno = 10
    ORDER BY empno;
BEGIN
    OPEN emp_cur_3;
    FETCH emp_cur_3 INTO v_empno, v_ename;
    ...
END;

```

If all the columns in a table are retrieved in the order defined in the table, `%ROWTYPE` can be used to define a record into which the `FETCH` statement will place the retrieved data. Each field within the record can then be accessed using dot notation.

```

CREATE OR REPLACE PROCEDURE cursor_example
IS
    v_emp_rec      emp%ROWTYPE;
    CURSOR emp_cur_1 IS SELECT * FROM emp;
BEGIN
    OPEN emp_cur_1;
    FETCH emp_cur_1 INTO v_emp_rec;
    DBMS_OUTPUT.PUT_LINE('Employee Number: ' || v_emp_rec.empno);
    DBMS_OUTPUT.PUT_LINE('Employee Name : ' || v_emp_rec.ename);
    ...
END;

```

3.8.4 Closing a Cursor

Once all the desired rows have been retrieved from the cursor result set, the cursor must be closed. Once closed, the result set is no longer accessible. The `CLOSE` statement appears as follows:

```
CLOSE name;
```

`name` is the identifier of a cursor that is currently open. Once a cursor is closed, it must not be closed again. However, once the cursor is closed, the `OPEN` statement can be issued again on the closed cursor and the query result set will be rebuilt after which the `FETCH` statement can then be used to retrieve the rows of the new result set.

The following example illustrates the use of the `CLOSE` statement:

```

CREATE OR REPLACE PROCEDURE cursor_example
IS
    v_emp_rec      emp%ROWTYPE;
    CURSOR emp_cur_1 IS SELECT * FROM emp;
BEGIN
    OPEN emp_cur_1;
    FETCH emp_cur_1 INTO v_emp_rec;
    DBMS_OUTPUT.PUT_LINE('Employee Number: ' || v_emp_rec.empno);
    DBMS_OUTPUT.PUT_LINE('Employee Name : ' || v_emp_rec.ename);
    CLOSE emp_cur_1;
END;

```

This procedure produces the following output when invoked. Employee number 7369, SMITH is the first row of the result set.

```
EXEC cursor_example;  
Employee Number: 7369  
Employee Name : SMITH
```

3.8.5 Using %ROWTYPE With Cursors

Using the `%ROWTYPE` attribute, a record can be defined that contains fields corresponding to all columns fetched from a cursor or cursor variable. Each field takes on the datatype of its corresponding column. The `%ROWTYPE` attribute is prefixed by a cursor name or cursor variable name.

```
record cursor%ROWTYPE;
```

`record` is an identifier assigned to the record. `cursor` is an explicitly declared cursor within the current scope.

The following example shows how you can use a cursor with `%ROWTYPE` to get information about which employee works in which department.

```
CREATE OR REPLACE PROCEDURE emp_info
IS
    CURSOR empcur IS SELECT ename, deptno FROM emp;
    myvar          empcur%ROWTYPE;
BEGIN
    OPEN empcur;
    LOOP
        FETCH empcur INTO myvar;
        EXIT WHEN empcur%NOTFOUND;
        DBMS_OUTPUT.PUT_LINE( myvar.ename || ' works in department '
                           || myvar.deptno );
    END LOOP;
    CLOSE empcur;
END;
```

The following is the output from this procedure.

```
EXEC emp_info;

SMITH works in department 20
ALLEN works in department 30
WARD works in department 30
JONES works in department 20
MARTIN works in department 30
BLAKE works in department 30
CLARK works in department 10
SCOTT works in department 20
KING works in department 10
TURNER works in department 30
ADAMS works in department 20
JAMES works in department 30
FORD works in department 20
MILLER works in department 10
```

3.8.6 Cursor Attributes

Each cursor has a set of attributes associated with it that allows the program to test the state of the cursor. These attributes are %ISOPEN, %FOUND, %NOTFOUND, and %ROWCOUNT. These attributes are described in the following sections.

3.8.6.1 %ISOPEN

The %ISOPEN attribute is used to test whether or not a cursor is open.

cursor_name%ISOPEN

cursor_name is the name of the cursor for which a BOOLEAN data type of TRUE will be returned if the cursor is open, FALSE otherwise.

The following is an example of using %ISOPEN.

```
CREATE OR REPLACE PROCEDURE cursor_example
IS
    ...
    CURSOR emp_cur_1 IS SELECT * FROM emp;
    ...
BEGIN
    ...
    IF emp_cur_1%ISOPEN THEN
        NULL;
    ELSE
        OPEN emp_cur_1;
    END IF;
    FETCH emp_cur_1 INTO ...
    ...
END;
```

3.8.6.2 %FOUND

The %FOUND attribute is used to test whether or not a row is retrieved from the result set of the specified cursor after a `FETCH` on the cursor.

cursor_name%FOUND

cursor_name is the name of the cursor for which a BOOLEAN data type of TRUE will be returned if a row is retrieved from the result set of the cursor after a `FETCH`.

After the last row of the result set has been `FETCHED` the next `FETCH` results in %FOUND returning FALSE. FALSE is also returned after the first `FETCH` if there are no rows in the result set to begin with.

Referencing `%FOUND` on a cursor before it is opened or after it is closed results in an `INVALID_CURSOR` exception being thrown.

`%FOUND` returns `null` if it is referenced when the cursor is open, but before the first `FETCH`.

The following example uses `%FOUND`.

```
CREATE OR REPLACE PROCEDURE cursor_example
IS
    v_emp_rec      emp%ROWTYPE;
    CURSOR emp_cur_1 IS SELECT * FROM emp;
BEGIN
    OPEN emp_cur_1;
    DBMS_OUTPUT.PUT_LINE('EMPNO      ENAME');
    DBMS_OUTPUT.PUT_LINE('-----  -----');
    FETCH emp_cur_1 INTO v_emp_rec;
    WHILE emp_cur_1%FOUND LOOP
        DBMS_OUTPUT.PUT_LINE(v_emp_rec.empno || '      ' || v_emp_rec.ename);
        FETCH emp_cur_1 INTO v_emp_rec;
    END LOOP;
    CLOSE emp_cur_1;
END;
```

When the previous procedure is invoked, the output appears as follows:

```
EXEC cursor_example;

EMPNO      ENAME
-----  -----
7369       SMITH
7499       ALLEN
7521       WARD
7566       JONES
7654       MARTIN
7698       BLAKE
7782       CLARK
7788       SCOTT
7839       KING
7844       TURNER
7876       ADAMS
7900       JAMES
7902       FORD
7934       MILLER
```

3.8.6.3 %NOTFOUND

The `%NOTFOUND` attribute is the logical opposite of `%FOUND`.

`cursor_name%NOTFOUND`

`cursor_name` is the name of the cursor for which a `BOOLEAN` data type of `FALSE` will be returned if a row is retrieved from the result set of the cursor after a `FETCH`.

After the last row of the result set has been `FETCHED` the next `FETCH` results in `%NOTFOUND` returning `TRUE`. `TRUE` is also returned after the first `FETCH` if there are no rows in the result set to begin with.

Referencing `%NOTFOUND` on a cursor before it is opened or after it is closed, results in an `INVALID_CURSOR` exception being thrown.

`%NOTFOUND` returns `null` if it is referenced when the cursor is open, but before the first `FETCH`.

The following example uses `%NOTFOUND`.

```
CREATE OR REPLACE PROCEDURE cursor_example
IS
    v_emp_rec      emp%ROWTYPE;
    CURSOR emp_cur_1 IS SELECT * FROM emp;
BEGIN
    OPEN emp_cur_1;
    DBMS_OUTPUT.PUT_LINE('EMPNO      ENAME');
    DBMS_OUTPUT.PUT_LINE('-----  -----');
    LOOP
        FETCH emp_cur_1 INTO v_emp_rec;
        EXIT WHEN emp_cur_1%NOTFOUND;
        DBMS_OUTPUT.PUT_LINE(v_emp_rec.empno || '      ' || v_emp_rec.ename);
    END LOOP;
    CLOSE emp_cur_1;
END;
```

Similar to the prior example, this procedure produces the same output when invoked.

```
EXEC cursor_example;

EMPNO      ENAME
-----  -----
7369       SMITH
7499       ALLEN
7521       WARD
7566       JONES
7654       MARTIN
7698       BLAKE
7782       CLARK
7788       SCOTT
7839       KING
7844       TURNER
7876       ADAMS
7900       JAMES
7902       FORD
7934       MILLER
```

3.8.6.4 %ROWCOUNT

The `%ROWCOUNT` attribute returns an integer showing the number of rows `FETCHED` so far from the specified cursor.

```
cursor_name%ROWCOUNT
```

`cursor_name` is the name of the cursor for which `%ROWCOUNT` returns the number of rows retrieved thus far. After the last row has been retrieved, `%ROWCOUNT` remains set to the total number of rows returned until the cursor is closed at which point `%ROWCOUNT` will throw an `INVALID_CURSOR` exception if referenced.

Referencing `%ROWCOUNT` on a cursor before it is opened or after it is closed, results in an `INVALID_CURSOR` exception being thrown.

`%ROWCOUNT` returns 0 if it is referenced when the cursor is open, but before the first `FETCH`. `%ROWCOUNT` also returns 0 after the first `FETCH` when there are no rows in the result set to begin with.

The following example uses `%ROWCOUNT`.

```
CREATE OR REPLACE PROCEDURE cursor_example
IS
    v_emp_rec      emp%ROWTYPE;
    CURSOR emp_cur_1 IS SELECT * FROM emp;
BEGIN
    OPEN emp_cur_1;
    DBMS_OUTPUT.PUT_LINE('EMPNO      ENAME');
    DBMS_OUTPUT.PUT_LINE('-----      -----');
    LOOP
        FETCH emp_cur_1 INTO v_emp_rec;
        EXIT WHEN emp_cur_1%NOTFOUND;
        DBMS_OUTPUT.PUT_LINE(v_emp_rec.empno || '      ' || v_emp_rec.ename);
    END LOOP;
    DBMS_OUTPUT.PUT_LINE('*****');
    DBMS_OUTPUT.PUT_LINE(emp_cur_1%ROWCOUNT || ' rows were retrieved');
    CLOSE emp_cur_1;
END;
```

This procedure prints the total number of rows retrieved at the end of the employee list as follows:

```
EXEC cursor_example;

EMPNO      ENAME
-----      -----
7369       SMITH
7499       ALLEN
7521       WARD
7566       JONES
7654       MARTIN
7698       BLAKE
7782       CLARK
```

```

77 88      SCOTT
78 39      KING
78 44      TURNER
78 76      ADAMS
79 00      JAMES
79 02      FORD
79 34      MILLER
*****
14 rows were retrieved

```

3.8.6.5 Summary of Cursor States and Attributes

The following table summarizes the possible cursor states and the values returned by the cursor attributes.

Table 3-3 Cursor Attributes

Cursor State	%ISOPEN	%FOUND	%NOTFOUND	%ROWCOUNT
Before OPEN	False	INVALID_CURSOR Exception	INVALID_CURSOR Exception	INVALID_CURSOR Exception
After OPEN & Before 1st FETCH	True	Null	Null	0
After 1st Successful FETCH	True	True	False	1
After <i>n</i> th Successful FETCH (last row)	True	True	False	<i>n</i>
After <i>n</i> +1st FETCH (after last row)	True	False	True	<i>n</i>
After CLOSE	False	INVALID_CURSOR Exception	INVALID_CURSOR Exception	INVALID_CURSOR Exception

3.8.7 Cursor FOR Loop

In the cursor examples presented so far, the programming logic required to process the result set of a cursor included a statement to open the cursor, a loop construct to retrieve each row of the result set, a test for the end of the result set, and finally a statement to close the cursor. The *cursor FOR loop* is a loop construct that eliminates the need to individually code the statements just listed.

The cursor FOR loop opens a previously declared cursor, fetches all rows in the cursor result set, and then closes the cursor.

The syntax for creating a cursor FOR loop is as follows.

```

FOR record IN cursor
LOOP
    statements
END LOOP;

```

record is an identifier assigned to an implicitly declared record with definition, *cursor%ROWTYPE*.*cursor* is the name of a previously declared cursor. *statements* are one or more SPL statements. There must be at least one statement.

The following example shows the example from Section [3.8.6.3](#), modified to use a cursor FOR loop.

```
CREATE OR REPLACE PROCEDURE cursor_example
IS
    CURSOR emp_cur_1 IS SELECT * FROM emp;
BEGIN
    DBMS_OUTPUT.PUT_LINE('EMPNO      ENAME');
    DBMS_OUTPUT.PUT_LINE('-----  -----');
    FOR v_emp_rec IN emp_cur_1 LOOP
        DBMS_OUTPUT.PUT_LINE(v_emp_rec.empno || '      ' || v_emp_rec.ename);
    END LOOP;
END;
```

The same results are achieved as shown in the output below.

```
EXEC cursor_example;

EMPNO      ENAME
-----  -----
7369       SMITH
7499       ALLEN
7521       WARD
7566       JONES
7654       MARTIN
7698       BLAKE
7782       CLARK
7788       SCOTT
7839       KING
7844       TURNER
7876       ADAMS
7900       JAMES
7902       FORD
7934       MILLER
```

3.8.8 Parameterized Cursors

A user can also declare a static cursor that accepts parameters, and can pass values for those parameters when opening that cursor. In the following example we have created a parameterized cursor which will display the name and salary of all employees from the *emp* table that have a salary less than a specified value which is passed as a parameter.

```
DECLARE
    my_record      emp%ROWTYPE;
    CURSOR c1 (max_wage NUMBER) IS
        SELECT * FROM emp WHERE sal < max_wage;
BEGIN
    OPEN c1(2000);
    LOOP
        FETCH c1 INTO my_record;
        EXIT WHEN c1%NOTFOUND;
```

```
DBMS_OUTPUT.PUT_LINE('Name = ' || my_record.ename || ', salary = '
    || my_record.sal);
END LOOP;
CLOSE c1;
END;
```

So for example if we pass the value 2000 as `max_wage`, then we will only be shown the name and salary of all employees that have a salary less than 2000. The result of the above query is the following:

```
Name = SMITH, salary = 800.00
Name = ALLEN, salary = 1600.00
Name = WARD, salary = 1250.00
Name = MARTIN, salary = 1250.00
Name = TURNER, salary = 1500.00
Name = ADAMS, salary = 1100.00
Name = JAMES, salary = 950.00
Name = MILLER, salary = 1300.00
```

3.9 REF CURSORS and Cursor Variables

This section discusses another type of cursor that provides far greater flexibility than the previously discussed static cursors.

3.9.1 REF CURSOR Overview

A *cursor variable* is a cursor that actually contains a pointer to a query result set. The result set is determined by the execution of the `OPEN FOR` statement using the cursor variable.

A cursor variable is not tied to a single particular query like a static cursor. The same cursor variable may be opened a number of times with `OPEN FOR` statements containing different queries. Each time, a new result set is created from that query and made available via the cursor variable.

`REF_CURSOR` types may be passed as parameters to or from stored procedures and functions. The return type of a function may also be a `REF_CURSOR` type. This provides the capability to modularize the operations on a cursor into separate programs by passing a cursor variable between programs.

3.9.2 Declaring a Cursor Variable

SPL supports the declaration of a cursor variable using both the `SYS_REFCURSOR` built-in data type as well as creating a type of `REF_CURSOR` and then declaring a variable of that type. `SYS_REFCURSOR` is a `REF_CURSOR` type that allows any result set to be associated with it. This is known as a *weakly-typed* `REF_CURSOR`.

Only the declaration of `SYS_REFCURSOR` and user-defined `REF_CURSOR` variables are different. The remaining usage like opening the cursor, selecting into the cursor and closing the cursor is the same across both the cursor types. For the rest of this chapter our examples will primarily be making use of the `SYS_REFCURSOR` cursors. All you need to change in the examples to make them work for user defined `REF_CURSORS` is the declaration section.

Note: *Strongly-typed* `REF_CURSORS` require the result set to conform to a declared number and order of fields with compatible data types and can also optionally return a result set.

3.9.2.1 Declaring a `SYS_REFCURSOR` Cursor Variable

The following is the syntax for declaring a `SYS_REFCURSOR` cursor variable:

```
name SYS_REFCURSOR;
```

name is an identifier assigned to the cursor variable.

The following is an example of a `SYS_REFCURSOR` variable declaration.

```
DECLARE
    emp_refcur      SYS_REFCURSOR;
    ...
```

3.9.2.2 Declaring a User Defined REFCURSOR Type Variable

You must perform two distinct declaration steps in order to use a user defined `REF CURSOR` variable:

- Create a referenced cursor `TYPE`
- Declare the actual cursor variable based on that `TYPE`

The syntax for creating a user defined `REF CURSOR` type is as follows:

```
TYPE cursor_type_name IS REF CURSOR [RETURN return_type];
```

The following is an example of a cursor variable declaration.

```
DECLARE
    TYPE emp_cur_type IS REF CURSOR RETURN emp%ROWTYPE;
    my_rec emp_cur_type;
    ...
```

3.9.3 Opening a Cursor Variable

Once a cursor variable is declared, it must be opened with an associated `SELECT` command. The `OPEN FOR` statement specifies the `SELECT` command to be used to create the result set.

```
OPEN name FOR query;
```

name is the identifier of a previously declared cursor variable. *query* is a `SELECT` command that determines the result set when the statement is executed. The value of the cursor variable after the `OPEN FOR` statement is executed identifies the result set.

In the following example, the result set is a list of employee numbers and names from a selected department. Note that a variable or parameter can be used in the `SELECT` command anywhere an expression can normally appear. In this case a parameter is used in the equality test for department number.

```
CREATE OR REPLACE PROCEDURE emp_by_dept (
    p_deptno          emp.deptno%TYPE
```

```

)
IS
    emp_refcur      SYS_REFCURSOR;
BEGIN
    OPEN emp_refcur FOR SELECT empno, ename FROM emp WHERE deptno = p_deptno;
    ...

```

3.9.4 Fetching Rows From a Cursor Variable

After a cursor variable is opened, rows may be retrieved from the result set using the `FETCH` statement. See Section [3.8.3](#) for details on using the `FETCH` statement to retrieve rows from a result set.

In the example below, a `FETCH` statement has been added to the previous example so now the result set is returned into two variables and then displayed. Note that the cursor attributes used to determine cursor state of static cursors can also be used with cursor variables. See Section [3.8.6](#) for details on cursor attributes.

```

CREATE OR REPLACE PROCEDURE emp_by_dept (
    p_deptno          emp.deptno%TYPE
)
IS
    emp_refcur      SYS_REFCURSOR;
    v_empno          emp.empno%TYPE;
    v_ename          emp.ename%TYPE;
BEGIN
    OPEN emp_refcur FOR SELECT empno, ename FROM emp WHERE deptno = p_deptno;
    DBMS_OUTPUT.PUT_LINE('EMPNO      ENAME');
    DBMS_OUTPUT.PUT_LINE('-----  -----');
    LOOP
        FETCH emp_refcur INTO v_empno, v_ename;
        EXIT WHEN emp_refcur%NOTFOUND;
        DBMS_OUTPUT.PUT_LINE(v_empno || '      ' || v_ename);
    END LOOP;
    ...

```

3.9.5 Closing a Cursor Variable

Use the `CLOSE` statement described in Section [3.8.4](#) to release the result set.

Note: Unlike static cursors, a cursor variable does not have to be closed before it can be re-opened again. The result set from the previous open will be lost.

The example is completed with the addition of the `CLOSE` statement.

```

CREATE OR REPLACE PROCEDURE emp_by_dept (
    p_deptno          emp.deptno%TYPE
)
IS
    emp_refcur      SYS_REFCURSOR;
    v_empno          emp.empno%TYPE;
    v_ename          emp.ename%TYPE;

```

```

BEGIN
    OPEN emp_refcur FOR SELECT empno, ename FROM emp WHERE deptno = p_deptno;
    DBMS_OUTPUT.PUT_LINE('EMPNO      ENAME');
    DBMS_OUTPUT.PUT_LINE('-----  -----');
    LOOP
        FETCH emp_refcur INTO v_empno, v_ename;
        EXIT WHEN emp_refcur%NOTFOUND;
        DBMS_OUTPUT.PUT_LINE(v_empno || '      ' || v_ename);
    END LOOP;
    CLOSE emp_refcur;
END;

```

The following is the output when this procedure is executed.

```

EXEC emp_by_dept(20)

EMPNO      ENAME
-----  -----
7369       SMITH
7566       JONES
7788       SCOTT
7876       ADAMS
7902       FORD

```

3.9.6 Usage Restrictions

The following are restrictions on cursor variable usage.

- Comparison operators cannot be used to test cursor variables for equality, inequality, null, or not null
- Null cannot be assigned to a cursor variable
- The value of a cursor variable cannot be stored in a database column
- Static cursors and cursor variables are not interchangeable. For example, a static cursor cannot be used in an `OPEN FOR` statement.

In addition the following table shows the permitted parameter modes for a cursor variable used as a procedure or function parameter depending upon the operations on the cursor variable within the procedure or function.

Table 3-4 Permitted Cursor Variable Parameter Modes

Operation	IN	IN OUT	OUT
OPEN	No	Yes	No
FETCH	Yes	Yes	No
CLOSE	Yes	Yes	No

So for example, if a procedure performs all three operations, `OPEN FOR`, `FETCH`, and `CLOSE` on a cursor variable declared as the procedure's formal parameter, then that parameter must be declared with `IN OUT` mode.

3.9.7 Examples

The following examples demonstrate cursor variable usage.

3.9.7.1 Returning a REF CURSOR From a Function

In the following example the cursor variable is opened with a query that selects employees with a given job. Note that the cursor variable is specified in this function's RETURN statement so the result set is made available to the caller of the function.

```
CREATE OR REPLACE FUNCTION emp_by_job (p_job VARCHAR2)
RETURN SYS_REFCURSOR
IS
    emp_refcur      SYS_REFCURSOR;
BEGIN
    OPEN emp_refcur FOR SELECT empno, ename FROM emp WHERE job = p_job;
    RETURN emp_refcur;
END;
```

This function is invoked in the following anonymous block by assigning the function's return value to a cursor variable declared in the anonymous block's declaration section. The result set is fetched using this cursor variable and then it is closed.

```
DECLARE
    v_empno        emp.empno%TYPE;
    v_ename        emp.ename%TYPE;
    v_job          emp.job%TYPE := 'SALESMAN';
    v_emp_refcur   SYS_REFCURSOR;
BEGIN
    DBMS_OUTPUT.PUT_LINE('EMPLOYEES WITH JOB ' || v_job);
    DBMS_OUTPUT.PUT_LINE('EMPNO    ENAME');
    DBMS_OUTPUT.PUT_LINE('-----  -----');
    v_emp_refcur := emp_by_job(v_job);
    LOOP
        FETCH v_emp_refcur INTO v_empno, v_ename;
        EXIT WHEN v_emp_refcur%NOTFOUND;
        DBMS_OUTPUT.PUT_LINE(v_empno || '    ' || v_ename);
    END LOOP;
    CLOSE v_emp_refcur;
END;
```

The following is the output when the anonymous block is executed.

EMPLOYEES WITH JOB SALESMAN	
EMPNO	ENAME
-----	-----
7499	ALLEN
7521	WARD
7654	MARTIN
7844	TURNER

3.9.7.2 Modularizing Cursor Operations

The following example illustrates how the various operations on cursor variables can be modularized into separate programs.

The following procedure opens the given cursor variable with a `SELECT` command that retrieves all rows.

```
CREATE OR REPLACE PROCEDURE open_all_emp (
    p_emp_refcur      IN OUT SYS_REFCURSOR
)
IS
BEGIN
    OPEN p_emp_refcur FOR SELECT empno, ename FROM emp;
END;
```

This variation opens the given cursor variable with a `SELECT` command that retrieves all rows, but of a given department.

```
CREATE OR REPLACE PROCEDURE open_emp_by_dept (
    p_emp_refcur      IN OUT SYS_REFCURSOR,
    p_deptno          emp.deptno%TYPE
)
IS
BEGIN
    OPEN p_emp_refcur FOR SELECT empno, ename FROM emp
        WHERE deptno = p_deptno;
END;
```

This third variation opens the given cursor variable with a `SELECT` command that retrieves all rows, but from a different table. Also note that the function's return value is the opened cursor variable.

```
CREATE OR REPLACE FUNCTION open_dept (
    p_dept_refcur     IN OUT SYS_REFCURSOR
) RETURN SYS_REFCURSOR
IS
    v_dept_refcur     SYS_REFCURSOR;
BEGIN
    v_dept_refcur := p_dept_refcur;
    OPEN v_dept_refcur FOR SELECT deptno, dname FROM dept;
    RETURN v_dept_refcur;
END;
```

This procedure fetches and displays a cursor variable result set consisting of employee number and name.

```
CREATE OR REPLACE PROCEDURE fetch_emp (
    p_emp_refcur      IN OUT SYS_REFCURSOR
)
IS
    v_empno           emp.empno%TYPE;
    v_ename            emp.ename%TYPE;
BEGIN
    DBMS_OUTPUT.PUT_LINE('EMPNO      ENAME');
```

```

DBMS_OUTPUT.PUT_LINE('-----');
LOOP
    FETCH p_emp_refcur INTO v_empno, v_ename;
    EXIT WHEN p_emp_refcur%NOTFOUND;
    DBMS_OUTPUT.PUT_LINE(v_empno || '      ' || v_ename);
END LOOP;
END;

```

This procedure fetches and displays a cursor variable result set consisting of department number and name.

```

CREATE OR REPLACE PROCEDURE fetch_dept (
    p_dept_refcur IN SYS_REFCURSOR
)
IS
    v_deptno      dept.deptno%TYPE;
    v_dname       dept.dname%TYPE;
BEGIN
    DBMS_OUTPUT.PUT_LINE('DEPT      DNAME');
    DBMS_OUTPUT.PUT_LINE('----  -----');
    LOOP
        FETCH p_dept_refcur INTO v_deptno, v_dname;
        EXIT WHEN p_dept_refcur%NOTFOUND;
        DBMS_OUTPUT.PUT_LINE(v_deptno || '      ' || v_dname);
    END LOOP;
END;

```

This procedure closes the given cursor variable.

```

CREATE OR REPLACE PROCEDURE close_refcur (
    p_refcur      IN OUT SYS_REFCURSOR
)
IS
BEGIN
    CLOSE p_refcur;
END;

```

The following anonymous block executes all the previously described programs.

```

DECLARE
    gen_refcur      SYS_REFCURSOR;
BEGIN
    DBMS_OUTPUT.PUT_LINE('ALL EMPLOYEES');
    open_all_emp(gen_refcur);
    fetch_emp(gen_refcur);
    DBMS_OUTPUT.PUT_LINE('*****');

    DBMS_OUTPUT.PUT_LINE('EMPLOYEES IN DEPT #10');
    open_emp_by_dept(gen_refcur, 10);
    fetch_emp(gen_refcur);
    DBMS_OUTPUT.PUT_LINE('*****');

    DBMS_OUTPUT.PUT_LINE('DEPARTMENTS');
    fetch_dept(open_dept(gen_refcur));
    DBMS_OUTPUT.PUT_LINE('*****');

    close_refcur(gen_refcur);
END;

```

The following is the output from the anonymous block.

```

ALL EMPLOYEES
EMPNO    ENAME
-----
7369     SMITH
7499     ALLEN
7521     WARD
7566     JONES
7654     MARTIN
7698     BLAKE
7782     CLARK
7788     SCOTT
7839     KING
7844     TURNER
7876     ADAMS
7900     JAMES
7902     FORD
7934     MILLER
*****
EMPLOYEES IN DEPT #10
EMPNO    ENAME
-----
7782     CLARK
7839     KING
7934     MILLER
*****
DEPARTMENTS
DEPT      DNAME
-----
10       ACCOUNTING
20       RESEARCH
30       SALES
40       OPERATIONS
*****
```

3.9.8 Dynamic Queries With REF CURSORs

Advanced Server also supports dynamic queries via the `OPEN FOR USING` statement. A string literal or string variable is supplied in the `OPEN FOR USING` statement to the `SELECT` command.

```
OPEN name FOR dynamic_string
[ USING bind_arg [, bind_arg_2 ] ...];
```

`name` is the identifier of a previously declared cursor variable. `dynamic_string` is a string literal or string variable containing a `SELECT` command (without the terminating semi-colon). `bind_arg`, `bind_arg_2`... are bind arguments that are used to pass variables to corresponding placeholders in the `SELECT` command when the cursor variable is opened. The placeholders are identifiers prefixed by a colon character.

The following is an example of a dynamic query using a string literal.

```
CREATE OR REPLACE PROCEDURE dept_query
IS
    emp_refcur      SYS_REFCURSOR;
    v_empno         emp.empno%TYPE;
    v_ename         emp.ename%TYPE;
BEGIN
    OPEN emp_refcur FOR 'SELECT empno, ename FROM emp WHERE deptno = 30' ||
        ' AND sal >= 1500';
    DBMS_OUTPUT.PUT_LINE('EMPNO      ENAME');
    DBMS_OUTPUT.PUT_LINE('-----  -----');
    LOOP
        FETCH emp_refcur INTO v_empno, v_ename;
        EXIT WHEN emp_refcur%NOTFOUND;
        DBMS_OUTPUT.PUT_LINE(v_empno || '      ' || v_ename);
    END LOOP;
    CLOSE emp_refcur;
END;
```

The following is the output when the procedure is executed.

```
EXEC dept_query;

EMPNO      ENAME
-----  -----
7499       ALLEN
7698       BLAKE
7844       TURNER
```

In the next example, the previous query is modified to use bind arguments to pass the query parameters.

```
CREATE OR REPLACE PROCEDURE dept_query (
    p_deptno      emp.deptno%TYPE,
    p_sal         emp.sal%TYPE
)
IS
    emp_refcur      SYS_REFCURSOR;
    v_empno         emp.empno%TYPE;
    v_ename         emp.ename%TYPE;
BEGIN
    OPEN emp_refcur FOR 'SELECT empno, ename FROM emp WHERE deptno = :dept' ||
        ' AND sal >= :sal' USING p_deptno, p_sal;
    DBMS_OUTPUT.PUT_LINE('EMPNO      ENAME');
    DBMS_OUTPUT.PUT_LINE('-----  -----');
    LOOP
        FETCH emp_refcur INTO v_empno, v_ename;
        EXIT WHEN emp_refcur%NOTFOUND;
        DBMS_OUTPUT.PUT_LINE(v_empno || '      ' || v_ename);
    END LOOP;
    CLOSE emp_refcur;
END;
```

The following is the resulting output.

```
EXEC dept_query(30, 1500);
```

EMPNO	ENAME
7499	ALLEN
7698	BLAKE
7844	TURNER

Finally, a string variable is used to pass the SELECT providing the most flexibility.

```
CREATE OR REPLACE PROCEDURE dept_query (
    p_deptno      emp.deptno%TYPE,
    p_sal         emp.sal%TYPE
)
IS
    emp_refcur      SYS_REFCURSOR;
    v_empno        emp.empno%TYPE;
    v_ename        emp.ename%TYPE;
    p_query_string  VARCHAR2(100);
BEGIN
    p_query_string := 'SELECT empno, ename FROM emp WHERE ' ||
                      'deptno = :dept AND sal >= :sal';
    OPEN emp_refcur FOR p_query_string USING p_deptno, p_sal;
    DBMS_OUTPUT.PUT_LINE('EMPNO    ENAME');
    DBMS_OUTPUT.PUT_LINE('-----  -----');
    LOOP
        FETCH emp_refcur INTO v_empno, v_ename;
        EXIT WHEN emp_refcur%NOTFOUND;
        DBMS_OUTPUT.PUT_LINE(v_empno || '    ' || v_ename);
    END LOOP;
    CLOSE emp_refcur;
END;
EXEC dept_query(20, 1500);

EMPNO    ENAME
-----  -----
7566    JONES
7788    SCOTT
7902    FORD
```

3.10 Collections

A *collection* is a set of ordered data items with the same data type. Generally, the data item is a scalar field, but may also be a user-defined type such as a record type or an object type as long as the structure and the data types that comprise each field of the user-defined type are the same for each element in the set. Each particular data item in the set is referenced by using subscript notation within a pair of parentheses.

Note: Multilevel collections (that is, where the data item of a collection is another collection) are not supported.

The most commonly known type of collection is an array. In Advanced Server, the supported collection types are *associative arrays* (formerly called *index-by-tables* in Oracle), *nested tables*, and *varrays*.

The general steps for using a collection are the following:

- A collection of the desired type must be defined. This can be done in the declaration section of an SPL program, which results in a *local type* that is accessible only within that program. For nested table and varray types this can also be done using the `CREATE TYPE` command, which creates a persistent, *standalone type* that can be referenced by any SPL program in the database.
- Variables of the collection type are declared. The collection associated with the declared variable is said to be *uninitialized* at this point if there is no value assignment made as part of the variable declaration.
- Uninitialized collections of nested tables and varrays are null. A *null collection* does not yet exist. Generally, a `COLLECTION_IS_NULL` exception is thrown if a collection method is invoked on a null collection.
- Uninitialized collections of associative arrays exist, but have no elements. An existing collection with no elements is called an *empty collection*.
- To initialize a null collection, you must either make it an empty collection or assign a non-null value to it. Generally, a null collection is initialized by using its *constructor*.
- To add elements to an empty associative array, you can simply assign values to its keys. For nested tables and varrays, generally its constructor is used to assign initial values to the nested table or varray. For nested tables and varrays, the `EXTEND` method is then used to grow the collection beyond its initial size established by the constructor.

The specific process for each collection type is described in the following sections.

3.10.1 **Associative Arrays**

An *associative array* is a type of collection that associates a unique key with a value. The key does not have to be numeric, but can be character data as well.

An associative array has the following characteristics:

- An *associative array type* must be defined after which *array variables* can be declared of that array type. Data manipulation occurs using the array variable.
- When an array variable is declared, the associative array is created, but it is empty - just start assigning values to key values.
- The key can be any negative integer, positive integer, or zero if `INDEX BY BINARY_INTEGER` or `PLS_INTEGER` is specified.
- The key can be character data if `INDEX BY VARCHAR2` is specified.
- There is no pre-defined limit on the number of elements in the array - it grows dynamically as elements are added.
- The array can be sparse - there may be gaps in the assignment of values to keys.
- An attempt to reference an array element that has not been assigned a value will result in an exception.

The `TYPE IS TABLE OF ... INDEX BY` statement is used to define an associative array type.

```
TYPE assotype IS TABLE OF { datatype | rectype | objtype }
    INDEX BY { BINARY_INTEGER | PLS_INTEGER | VARCHAR2(n) };
```

assotype is an identifier assigned to the array type. *datatype* is a scalar data type such as `VARCHAR2` or `NUMBER`. *rectype* is a previously defined record type. *objtype* is a previously defined object type. *n* is the maximum length of a character key.

In order to make use of the array, a *variable* must be declared with that array type. The following is the syntax for declaring an array variable.

```
array assotype
```

array is an identifier assigned to the associative array. *assotype* is the identifier of a previously defined array type.

An element of the array is referenced using the following syntax.

```
array(n) [.field ]
```

array is the identifier of a previously declared array. *n* is the key value, type-compatible with the data type given in the `INDEX BY` clause. If the array type of *array* is defined from a record type or object type, then `[.field]` must reference an individual field within the record type or attribute within the object type from which the array type is defined. Alternatively, the entire record can be referenced by omitting `[.field]`.

The following example reads the first ten employee names from the `emp` table, stores them in an array, then displays the results from the array.

```

DECLARE
    TYPE emp_arr_typ IS TABLE OF VARCHAR2(10) INDEX BY BINARY_INTEGER;
    emp_arr          emp_arr_typ;
    CURSOR emp_cur IS SELECT ename FROM emp WHERE ROWNUM <= 10;
    i                INTEGER := 0;
BEGIN
    FOR r_emp IN emp_cur LOOP
        i := i + 1;
        emp_arr(i) := r_emp.ename;
    END LOOP;
    FOR j IN 1..10 LOOP
        DBMS_OUTPUT.PUT_LINE(emp_arr(j));
    END LOOP;
END;

```

The above example produces the following output:

```

SMITH
ALLEN
WARD
JONES
MARTIN
BLAKE
CLARK
SCOTT
KING
TURNER

```

The previous example is now modified to use a record type in the array definition.

```

DECLARE
    TYPE emp_rec_typ IS RECORD (
        empno      NUMBER(4),
        ename      VARCHAR2(10)
    );
    TYPE emp_arr_typ IS TABLE OF emp_rec_typ INDEX BY BINARY_INTEGER;
    emp_arr          emp_arr_typ;
    CURSOR emp_cur IS SELECT empno, ename FROM emp WHERE ROWNUM <= 10;
    i                INTEGER := 0;
BEGIN
    DBMS_OUTPUT.PUT_LINE('EMPNO    ENAME');
    DBMS_OUTPUT.PUT_LINE('-----  -----');
    FOR r_emp IN emp_cur LOOP
        i := i + 1;
        emp_arr(i).empno := r_emp.empno;
        emp_arr(i).ename := r_emp.ename;
    END LOOP;
    FOR j IN 1..10 LOOP
        DBMS_OUTPUT.PUT_LINE(emp_arr(j).empno || '  ' ||
                             emp_arr(j).ename);
    END LOOP;
END;

```

The following is the output from this anonymous block.

EMPNO	ENAME
-----	-----
7369	SMITH
7499	ALLEN
7521	WARD

```

7566      JONES
7654      MARTIN
7698      BLAKE
7782      CLARK
7788      SCOTT
7839      KING
7844      TURNER

```

The `emp%ROWTYPE` attribute could be used to define `emp_arr_typ` instead of using the `emp_rec_typ` record type as shown in the following.

```

DECLARE
    TYPE emp_arr_typ IS TABLE OF emp%ROWTYPE INDEX BY BINARY_INTEGER;
    emp_arr        emp_arr_typ;
    CURSOR emp_cur IS SELECT empno, ename FROM emp WHERE ROWNUM <= 10;
    i              INTEGER := 0;
BEGIN
    DBMS_OUTPUT.PUT_LINE('EMPNO      ENAME');
    DBMS_OUTPUT.PUT_LINE('-----  -----');
    FOR r_emp IN emp_cur LOOP
        i := i + 1;
        emp_arr(i).empno := r_emp.empno;
        emp_arr(i).ename := r_emp.ename;
    END LOOP;
    FOR j IN 1..10 LOOP
        DBMS_OUTPUT.PUT_LINE(emp_arr(j).empno || '    ' ||
                             emp_arr(j).ename);
    END LOOP;
END;

```

The results are the same as in the prior example.

Instead of assigning each field of the record individually, a record level assignment can be made from `r_emp` to `emp_arr`.

```

DECLARE
    TYPE emp_rec_typ IS RECORD (
        empno      NUMBER(4),
        ename      VARCHAR2(10)
    );
    TYPE emp_arr_typ IS TABLE OF emp_rec_typ INDEX BY BINARY_INTEGER;
    emp_arr        emp_arr_typ;
    CURSOR emp_cur IS SELECT empno, ename FROM emp WHERE ROWNUM <= 10;
    i              INTEGER := 0;
BEGIN
    DBMS_OUTPUT.PUT_LINE('EMPNO      ENAME');
    DBMS_OUTPUT.PUT_LINE('-----  -----');
    FOR r_emp IN emp_cur LOOP
        i := i + 1;
        emp_arr(i) := r_emp;
    END LOOP;
    FOR j IN 1..10 LOOP
        DBMS_OUTPUT.PUT_LINE(emp_arr(j).empno || '    ' ||
                             emp_arr(j).ename);
    END LOOP;
END;

```

The key of an associative array can be character data as shown in the following example.

```

DECLARE
    TYPE job_arr_typ IS TABLE OF NUMBER INDEX BY VARCHAR2(9);
    job_arr        job_arr_typ;
BEGIN
    job_arr('ANALYST') := 100;
    job_arr('CLERK')   := 200;
    job_arr('MANAGER') := 300;
    job_arr('SALESMAN') := 400;
    job_arr('PRESIDENT') := 500;
    DBMS_OUTPUT.PUT_LINE('ANALYST : ' || job_arr('ANALYST'));
    DBMS_OUTPUT.PUT_LINE('CLERK : ' || job_arr('CLERK'));
    DBMS_OUTPUT.PUT_LINE('MANAGER : ' || job_arr('MANAGER'));
    DBMS_OUTPUT.PUT_LINE('SALESMAN : ' || job_arr('SALESMAN'));
    DBMS_OUTPUT.PUT_LINE('PRESIDENT: ' || job_arr('PRESIDENT'));
END;

ANALYST : 100
CLERK   : 200
MANAGER : 300
SALESMAN : 400
PRESIDENT: 500

```

3.10.2 Nested Tables

A *nested table* is a type of collection that associates a positive integer with a value. A nested table has the following characteristics:

- A *nested table type* must be defined after which *nested table variables* can be declared of that nested table type. Data manipulation occurs using the nested table variable, or simply, “table” for short.
- When a nested table variable is declared, the nested table initially does not exist (it is a null collection). The null table must be initialized with a *constructor*. You can also initialize the table by using an assignment statement where the right-hand side of the assignment is an initialized table of the same type. **Note:** Initialization of a nested table is mandatory in Oracle, but optional in SPL.
- The key is a positive integer.
- The constructor establishes the number of elements in the table. The `EXTEND` method adds additional elements to the table. See Section 3.11 for information on collection methods. **Note:** Usage of the constructor to establish the number of elements in the table and usage of the `EXTEND` method to add additional elements to the table are mandatory in Oracle, but optional in SPL.
- The table can be sparse - there may be gaps in the assignment of values to keys.
- An attempt to reference a table element beyond its initialized or extended size will result in a `SUBSCRIPT_BEYOND_COUNT` exception.

The `TYPE IS TABLE` statement is used to define a nested table type within the declaration section of an SPL program.

```
TYPE tbltype IS TABLE OF { datatype | rectype | objtype };
```

tbltype is an identifier assigned to the nested table type. *datatype* is a scalar data type such as VARCHAR2 or NUMBER. *rectype* is a previously defined record type. *objtype* is a previously defined object type.

Note: You can use the CREATE TYPE command to define a nested table type that is available to all SPL programs in the database. See the Database Compatibility for Oracle Developers Reference Guide for more information about the CREATE TYPE command.

In order to make use of the table, a *variable* must be declared of that nested table type. The following is the syntax for declaring a table variable.

```
table tbltype
```

table is an identifier assigned to the nested table. *tbltype* is the identifier of a previously defined nested table type.

A nested table is initialized using the nested table type's constructor.

```
tbltype ([ { expr1 | NULL } [, { expr2 | NULL } ] [, ...] ])
```

tbltype is the identifier of the nested table type's constructor, which has the same name as the nested table type. *expr1*, *expr2*, ... are expressions that are type-compatible with the element type of the table. If NULL is specified, the corresponding element is set to null. If the parameter list is empty, then an empty nested table is returned, which means there are no elements in the table. If the table is defined from an object type, then *exprn* must return an object of that object type. The object can be the return value of a function or the object type's constructor, or the object can be an element of another nested table of the same type.

If a collection method other than EXISTS is applied to an uninitialized nested table, a COLLECTION_IS_NULL exception is thrown. See Section 3.11 for information on collection methods.

The following is an example of a constructor for a nested table:

```
DECLARE
    TYPE nested_typ IS TABLE OF CHAR(1);
    v_nested      nested_typ := nested_typ('A', 'B');
```

An element of the table is referenced using the following syntax.

```
table(n) [.element ]
```

table is the identifier of a previously declared table. *n* is a positive integer. If the table type of *table* is defined from a record type or object type, then [.*element*] must

reference an individual field within the record type or attribute within the object type from which the nested table type is defined. Alternatively, the entire record or object can be referenced by omitting `[.element]`.

The following is an example of a nested table where it is known that there will be four elements.

```
DECLARE
    TYPE dname_tbl_typ IS TABLE OF VARCHAR2(14);
    dname_tbl        dname_tbl_typ;
    CURSOR dept_cur IS SELECT dname FROM dept ORDER BY dname;
    i                INTEGER := 0;
BEGIN
    dname_tbl := dname_tbl_typ(NULL, NULL, NULL, NULL);
    FOR r_dept IN dept_cur LOOP
        i := i + 1;
        dname_tbl(i) := r_dept.dname;
    END LOOP;
    DBMS_OUTPUT.PUT_LINE('DNAME');
    DBMS_OUTPUT.PUT_LINE('-----');
    FOR j IN 1..i LOOP
        DBMS_OUTPUT.PUT_LINE(dname_tbl(j));
    END LOOP;
END;
```

The above example produces the following output:

```
DNAME
-----
ACCOUNTING
OPERATIONS
RESEARCH
SALES
```

The following example reads the first ten employee names from the `emp` table, stores them in a nested table, then displays the results from the table. The SPL code is written to assume that the number of employees to be returned is not known beforehand.

```
DECLARE
    TYPE emp_rec_typ IS RECORD (
        empno      NUMBER(4),
        ename      VARCHAR2(10)
    );
    TYPE emp_tbl_typ IS TABLE OF emp_rec_typ;
    emp_tbl     emp_tbl_typ;
    CURSOR emp_cur IS SELECT empno, ename FROM emp WHERE ROWNUM <= 10;
    i           INTEGER := 0;
BEGIN
    emp_tbl := emp_tbl_typ();
    DBMS_OUTPUT.PUT_LINE('EMPNO    ENAME');
    DBMS_OUTPUT.PUT_LINE('-----  -----');
    FOR r_emp IN emp_cur LOOP
        i := i + 1;
        emp_tbl.EXTEND;
        emp_tbl(i) := r_emp;
    END LOOP;
    FOR j IN 1..10 LOOP
```

```

        DBMS_OUTPUT.PUT_LINE(emp_tbl(j).empno || ' ' || 
        emp_tbl(j).ename);
    END LOOP;
END;

```

Note the creation of an empty table with the constructor `emp_tbl_typ()` as the first statement in the executable section of the anonymous block. The `EXTEND` collection method is then used to add an element to the table for each employee returned from the result set. See Section [3.11.4](#) for information on `EXTEND`.

The following is the output.

EMPNO	ENAME
7369	SMITH
7499	ALLEN
7521	WARD
7566	JONES
7654	MARTIN
7698	BLAKE
7782	CLARK
7788	SCOTT
7839	KING
7844	TURNER

The following example shows how a nested table of an object type can be used. First, an object type is created with attributes for the department name and location.

```

CREATE TYPE dept_obj_typ AS OBJECT (
    dname          VARCHAR2(14),
    loc            VARCHAR2(13)
);

```

The following anonymous block defines a nested table type whose element consists of the `dept_obj_typ` object type. A nested table variable is declared, initialized, and then populated from the `dept` table. Finally, the elements from the nested table are displayed.

```

DECLARE
    TYPE dept_tbl_typ IS TABLE OF dept_obj_typ;
    dept_tbl      dept_tbl_typ;
    CURSOR dept_cur IS SELECT dname, loc FROM dept ORDER BY dname;
    i             INTEGER := 0;
BEGIN
    dept_tbl := dept_tbl_typ(
        dept_obj_typ(NULL,NULL),
        dept_obj_typ(NULL,NULL),
        dept_obj_typ(NULL,NULL),
        dept_obj_typ(NULL,NULL),
        dept_obj_typ(NULL,NULL)
    );
    FOR r_dept IN dept_cur LOOP
        i := i + 1;
        dept_tbl(i).dname := r_dept.dname;
        dept_tbl(i).loc   := r_dept.loc;
    END LOOP;
    DBMS_OUTPUT.PUT_LINE('DNAME           LOC');
    DBMS_OUTPUT.PUT_LINE('-----       -----');
    FOR j IN 1..i LOOP

```

```

DBMS_OUTPUT.PUT_LINE(RPAD(dept_tbl(j).dname,14) || ' ' || 
dept_tbl(j).loc);
END LOOP;
END;

```

Note: The parameters comprising the nested table's constructor, `dept_tbl_typ`, are calls to the object type's constructor `dept_obj_typ`.

The following is the output from the anonymous block.

DNAM	LOC
ACCOUNTING	NEW YORK
OPERATIONS	BOSTON
RESEARCH	DALLAS
SALES	CHICAGO

3.10.3 Varrays

A *varray* or *variable-size array* is a type of collection that associates a positive integer with a value. In many respects, it is similar to a nested table.

A varray has the following characteristics:

- A *varray type* must be defined along with a maximum size limit. After the varray type is defined, *varray variables* can be declared of that varray type. Data manipulation occurs using the varray variable, or simply, “varray” for short. The number of elements in the varray cannot exceed the maximum size limit established in the varray type definition.
- When a varray variable is declared, the varray initially does not exist (it is a null collection). The null varray must be initialized with a *constructor*. You can also initialize the varray by using an assignment statement where the right-hand side of the assignment is an initialized varray of the same type.
- The key is a positive integer.
- The constructor establishes the number of elements in the varray, which must not exceed the maximum size limit. The `EXTEND` method can add additional elements to the varray up to the maximum size limit. See Section 3.11 for information on collection methods.
- Unlike a nested table, a varray cannot be sparse - there are no gaps in the assignment of values to keys.
- An attempt to reference a varray element beyond its initialized or extended size, but within the maximum size limit will result in a `SUBSCRIPT_BEYOND_COUNT` exception.
- An attempt to reference a varray element beyond the maximum size limit or extend a varray beyond the maximum size limit will result in a `SUBSCRIPT_OUTSIDE_LIMIT` exception.

The `TYPE IS VARRAY` statement is used to define a varray type within the declaration section of an SPL program.

```
TYPE varraytype IS { VARRAY | VARYING ARRAY } (maxsize)
OF { datatype | objtype };
```

`varraytype` is an identifier assigned to the varray type. `datatype` is a scalar data type such as `VARCHAR2` or `NUMBER`. `maxsize` is the maximum number of elements permitted in varrays of that type. `objtype` is a previously defined object type.

Note: The `CREATE TYPE` command can be used to define a varray type that is available to all SPL programs in the database. In order to make use of the varray, a *variable* must be declared of that varray type. The following is the syntax for declaring a varray variable.

```
varray varraytype
```

`varray` is an identifier assigned to the varray. `varraytype` is the identifier of a previously defined varray type.

A varray is initialized using the varray type's constructor.

```
varraytype ( [ { expr1 | NULL } [ , { expr2 | NULL } ]
[ , ... ] ] )
```

`varraytype` is the identifier of the varray type's constructor, which has the same name as the varray type. `expr1, expr2, ...` are expressions that are type-compatible with the element type of the varray. If `NULL` is specified, the corresponding element is set to null. If the parameter list is empty, then an empty varray is returned, which means there are no elements in the varray. If the varray is defined from an object type, then `exprn` must return an object of that object type. The object can be the return value of a function or the return value of the object type's constructor. The object can also be an element of another varray of the same varray type.

If a collection method other than `EXISTS` is applied to an uninitialized varray, a `COLLECTION_IS_NULL` exception is thrown. See Section 3.11 for information on collection methods.

The following is an example of a constructor for a varray:

```
DECLARE
  TYPE varray_typ IS VARRAY(2) OF CHAR(1);
  v_varray      varray_typ := varray_typ('A', 'B');
```

An element of the varray is referenced using the following syntax.

```
varray(n) [.element ]
```

varray is the identifier of a previously declared varray. *n* is a positive integer. If the varray type of *varray* is defined from an object type, then [.element] must reference an attribute within the object type from which the varray type is defined. Alternatively, the entire object can be referenced by omitting [.element].

The following is an example of a varray where it is known that there will be four elements.

```
DECLARE
    TYPE dname_varray_typ IS VARRAY(4) OF VARCHAR2(14);
    dname_varray    dname_varray_typ;
    CURSOR dept_cur IS SELECT dname FROM dept ORDER BY dname;
    i                INTEGER := 0;
BEGIN
    dname_varray := dname_varray_typ(NULL, NULL, NULL, NULL);
    FOR r_dept IN dept_cur LOOP
        i := i + 1;
        dname_varray(i) := r_dept.dname;
    END LOOP;
    DBMS_OUTPUT.PUT_LINE('DNAME');
    DBMS_OUTPUT.PUT_LINE('-----');
    FOR j IN 1..i LOOP
        DBMS_OUTPUT.PUT_LINE(dname_varray(j));
    END LOOP;
END;
```

The above example produces the following output:

```
DNAME
-----
ACCOUNTING
OPERATIONS
RESEARCH
SALES
```

3.11 Collection Methods

Collection methods are functions and procedures that provide useful information about a collection that can aid in the processing of data in the collection. The following sections discuss the collection methods supported by Advanced Server.

3.11.1 COUNT

COUNT is a method that returns the number of elements in a collection. The syntax for using COUNT is as follows:

```
collection.COUNT
```

collection is the name of a collection.

For a varray, COUNT always equals LAST.

The following example shows that an associative array can be sparsely populated (i.e., there are “gaps” in the sequence of assigned elements). COUNT includes only the elements that have been assigned a value.

```
DECLARE
    TYPE sparse_arr_typ IS TABLE OF NUMBER INDEX BY BINARY_INTEGER;
    sparse_arr      sparse_arr_typ;
BEGIN
    sparse_arr(-100)  := -100;
    sparse_arr(-10)   := -10;
    sparse_arr(0)     := 0;
    sparse_arr(10)    := 10;
    sparse_arr(100)   := 100;
    DBMS_OUTPUT.PUT_LINE('COUNT: ' || sparse_arr.COUNT);
END;
```

The following output shows that there are five populated elements included in COUNT.

```
COUNT: 5
```

3.11.2 DELETE

The DELETE method deletes entries from a collection. You can call the DELETE method in three different ways.

Use the first form of the DELETE method to remove all entries from a collection:

```
collection.DELETE
```

Use the second form of the `DELETE` method to remove the specified entry from a collection:

```
collection.DELETE(subscript)
```

Use the third form of the `DELETE` method to remove the entries that are within the range specified by `first_subscript` and `last_subscript` (including the entries for the `first_subscript` and the `last_subscript`) from a collection.

```
collection.DELETE(first_subscript, last_subscript)
```

If `first_subscript` and `last_subscript` refer to non-existent elements, elements that are in the range between the specified subscripts are deleted. If `first_subscript` is greater than `last_subscript`, or if you specify a value of `NULL` for one of the arguments, `DELETE` has no effect.

Note that when you delete an entry, the subscript remains in the collection; you can reuse the subscript with an alternate entry. If you specify a subscript that does not exist in the call to the `DELETE` method, `DELETE` does not raise an exception.

The following example demonstrates using the `DELETE` method to remove the element with subscript 0 from the collection:

```
DECLARE
    TYPE sparse_arr_typ IS TABLE OF NUMBER INDEX BY BINARY_INTEGER;
    sparse_arr    sparse_arr_typ;
    v_results     VARCHAR2(50);
    v_sub         NUMBER;
BEGIN
    sparse_arr(-100) := -100;
    sparse_arr(-10)  := -10;
    sparse_arr(0)    := 0;
    sparse_arr(10)   := 10;
    sparse_arr(100)  := 100;
    DBMS_OUTPUT.PUT_LINE('COUNT: ' || sparse_arr.COUNT);
    sparse_arr.DELETE(0);
    DBMS_OUTPUT.PUT_LINE('COUNT: ' || sparse_arr.COUNT);
    v_sub := sparse_arr.FIRST;
    WHILE v_sub IS NOT NULL LOOP
        IF sparse_arr(v_sub) IS NULL THEN
            v_results := v_results || 'NULL ';
        ELSE
            v_results := v_results || sparse_arr(v_sub) || ' ';
        END IF;
        v_sub := sparse_arr.NEXT(v_sub);
    END LOOP;
    DBMS_OUTPUT.PUT_LINE('Results: ' || v_results);
END;

COUNT: 5
COUNT: 4
Results: -100 -10 10 100
```

COUNT indicates that before the `DELETE` method, there were 5 elements in the collection; after the `DELETE` method was invoked, the collection contains 4 elements.

3.11.3 EXISTS

The `EXISTS` method verifies that a subscript exists within a collection. `EXISTS` returns `TRUE` if the subscript exists; if the subscript does not exist, `EXISTS` returns `FALSE`. The method takes a single argument; the `subscript` that you are testing for. The syntax is:

```
collection.EXISTS(subscript)
```

`collection` is the name of the collection.

`subscript` is the value that you are testing for. If you specify a value of `NULL`, `EXISTS` returns `false`.

The following example verifies that subscript number 10 exists within the associative array:

```
DECLARE
    TYPE sparse_arr_typ IS TABLE OF NUMBER INDEX BY BINARY_INTEGER;
    sparse_arr    sparse_arr_typ;
BEGIN
    sparse_arr(-100)  := -100;
    sparse_arr(-10)   := -10;
    sparse_arr(0)     := 0;
    sparse_arr(10)    := 10;
    sparse_arr(100)   := 100;
    DBMS_OUTPUT.PUT_LINE('The index exists: ' ||
        CASE WHEN sparse_arr.exists(10) = TRUE THEN 'true' ELSE 'false' END);
END;

The index exists: true
```

Some collection methods raise an exception if you call them with a subscript that does not exist within the specified collection. Rather than raising an error, the `EXISTS` method returns a value of `FALSE`.

3.11.4 EXTEND

The `EXTEND` method increases the size of a collection. There are three variations of the `EXTEND` method. The first variation appends a single `NULL` element to a collection; the syntax for the first variation is:

```
collection.EXTEND
```

`collection` is the name of a collection.

The following example demonstrates using the `EXTEND` method to append a single, null element to a collection:

```

DECLARE
    TYPE sparse_arr_typ IS TABLE OF NUMBER;
    sparse_arr      sparse_arr_typ := sparse_arr_typ(-100,-10,0,10,100);
    v_results       VARCHAR2(50);
BEGIN
    DBMS_OUTPUT.PUT_LINE('COUNT: ' || sparse_arr.COUNT);
    sparse_arr.EXTEND;
    DBMS_OUTPUT.PUT_LINE('COUNT: ' || sparse_arr.COUNT);
    FOR i IN sparse_arr.FIRST .. sparse_arr.LAST LOOP
        IF sparse_arr(i) IS NULL THEN
            v_results := v_results || 'NULL ';
        ELSE
            v_results := v_results || sparse_arr(i) || ' ';
        END IF;
    END LOOP;
    DBMS_OUTPUT.PUT_LINE('Results: ' || v_results);
END;

COUNT: 5
COUNT: 6
Results: -100 -10 0 10 100 NULL

```

`COUNT` indicates that before the `EXTEND` method, there were 5 elements in the collection; after the `EXTEND` method was invoked, the collection contains 6 elements.

The second variation of the `EXTEND` method appends a specified number of elements to the end of a collection.

`collection.EXTEND(count)`

`collection` is the name of a collection.

`count` is the number of null elements added to the end of the collection.

The following example demonstrates using the `EXTEND` method to append multiple null elements to a collection:

```

DECLARE
    TYPE sparse_arr_typ IS TABLE OF NUMBER;
    sparse_arr      sparse_arr_typ := sparse_arr_typ(-100,-10,0,10,100);
    v_results       VARCHAR2(50);
BEGIN
    DBMS_OUTPUT.PUT_LINE('COUNT: ' || sparse_arr.COUNT);
    sparse_arr.EXTEND(3);
    DBMS_OUTPUT.PUT_LINE('COUNT: ' || sparse_arr.COUNT);
    FOR i IN sparse_arr.FIRST .. sparse_arr.LAST LOOP
        IF sparse_arr(i) IS NULL THEN
            v_results := v_results || 'NULL ';
        ELSE
            v_results := v_results || sparse_arr(i) || ' ';
        END IF;
    END LOOP;
    DBMS_OUTPUT.PUT_LINE('Results: ' || v_results);
END;

```

```

END;

COUNT: 5
COUNT: 8
Results: -100 -10 0 10 100 NULL NULL NULL

```

COUNT indicates that before the EXTEND method, there were 5 elements in the collection; after the EXTEND method was invoked, the collection contains 8 elements.

The third variation of the EXTEND method appends a specified number of copies of a particular element to the end of a collection.

collection.EXTEND(count, index_number)

collection is the name of a collection.

count is the number of elements added to the end of the collection.

index_number is the subscript of the element that is being copied to the collection.

The following example demonstrates using the EXTEND method to append multiple copies of the second element to the collection:

```

DECLARE
    TYPE sparse_arr_typ IS TABLE OF NUMBER;
    sparse_arr      sparse_arr_typ := sparse_arr_typ(-100,-10,0,10,100);
    v_results       VARCHAR2(50);
BEGIN
    DBMS_OUTPUT.PUT_LINE('COUNT: ' || sparse_arr.COUNT);
    sparse_arr.EXTEND(3, 2);
    DBMS_OUTPUT.PUT_LINE('COUNT: ' || sparse_arr.COUNT);
    FOR i IN sparse_arr.FIRST .. sparse_arr.LAST LOOP
        IF sparse_arr(i) IS NULL THEN
            v_results := v_results || 'NULL ';
        ELSE
            v_results := v_results || sparse_arr(i) || ' ';
        END IF;
    END LOOP;
    DBMS_OUTPUT.PUT_LINE('Results: ' || v_results);
END;

COUNT: 5
COUNT: 8
Results: -100 -10 0 10 100 -10 -10 -10

```

COUNT indicates that before the EXTEND method, there were 5 elements in the collection; after the EXTEND method was invoked, the collection contains 8 elements.

Note: The EXTEND method cannot be used on a null or empty collection.

3.11.5 FIRST

`FIRST` is a method that returns the subscript of the first element in a collection. The syntax for using `FIRST` is as follows:

`collection.FIRST`

`collection` is the name of a collection.

The following example displays the first element of the associative array.

```
DECLARE
    TYPE sparse_arr_typ IS TABLE OF NUMBER INDEX BY BINARY_INTEGER;
    sparse_arr      sparse_arr_typ;
BEGIN
    sparse_arr(-100)  := -100;
    sparse_arr(-10)   := -10;
    sparse_arr(0)     := 0;
    sparse_arr(10)    := 10;
    sparse_arr(100)   := 100;
    DBMS_OUTPUT.PUT_LINE('FIRST element: ' || sparse_arr(sparse_arr.FIRST));
END;

FIRST element: -100
```

3.11.6 LAST

`LAST` is a method that returns the subscript of the last element in a collection. The syntax for using `LAST` is as follows:

`collection.LAST`

`collection` is the name of a collection.

The following example displays the last element of the associative array.

```
DECLARE
    TYPE sparse_arr_typ IS TABLE OF NUMBER INDEX BY BINARY_INTEGER;
    sparse_arr      sparse_arr_typ;
BEGIN
    sparse_arr(-100)  := -100;
    sparse_arr(-10)   := -10;
    sparse_arr(0)     := 0;
    sparse_arr(10)    := 10;
    sparse_arr(100)   := 100;
    DBMS_OUTPUT.PUT_LINE('LAST element: ' || sparse_arr(sparse_arr.LAST));
END;

LAST element: 100
```

3.11.7 LIMIT

`LIMIT` is a method that returns the maximum number of elements permitted in a collection. `LIMIT` is applicable only to varrays. The syntax for using `LIMIT` is as follows:

```
collection.LIMIT
```

collection is the name of a collection.

For an initialized varray, `LIMIT` returns the maximum size limit determined by the varray type definition. If the varray is uninitialized (that is, it is a null varray), an exception is thrown.

For an associative array or an initialized nested table, `LIMIT` returns `NULL`. If the nested table is uninitialized (that is, it is a null nested table), an exception is thrown.

3.11.8 NEXT

`NEXT` is a method that returns the subscript that follows a specified subscript. The method takes a single argument; the `subscript` that you are testing for.

```
collection.NEXT(subscript)
```

collection is the name of the collection.

If the specified subscript is less than the first subscript in the collection, the function returns the first subscript. If the subscript does not have a successor, `NEXT` returns `NULL`. If you specify a `NULL` subscript, `PRIOR` does not return a value.

The following example demonstrates using `NEXT` to return the subscript that follows subscript 10 in the associative array, `sparse_arr`:

```
DECLARE
    TYPE sparse_arr_typ IS TABLE OF NUMBER INDEX BY BINARY_INTEGER;
    sparse_arr    sparse_arr_typ;
BEGIN
    sparse_arr(-100)  := -100;
    sparse_arr(-10)   := -10;
    sparse_arr(0)     := 0;
    sparse_arr(10)    := 10;
    sparse_arr(100)   := 100;
    DBMS_OUTPUT.PUT_LINE('NEXT element: ' || sparse_arr.next(10));
END;

NEXT element: 100
```

3.11.9 PRIOR

The `PRIOR` method returns the subscript that precedes a specified subscript in a collection. The method takes a single argument; the `subscript` that you are testing for. The syntax is:

```
collection.PRIOR(subscript)
```

collection is the name of the collection.

If the subscript specified does not have a predecessor, `PRIOR` returns `NULL`. If the specified subscript is greater than the last subscript in the collection, the method returns the last subscript. If you specify a `NULL` subscript, `PRIOR` does not return a value.

The following example returns the subscript that precedes subscript `100` in the associative array, `sparse_arr`:

```
DECLARE
    TYPE sparse_arr_typ IS TABLE OF NUMBER INDEX BY BINARY_INTEGER;
    sparse_arr      sparse_arr_typ;
BEGIN
    sparse_arr(-100)  := -100;
    sparse_arr(-10)   := -10;
    sparse_arr(0)     := 0;
    sparse_arr(10)    := 10;
    sparse_arr(100)   := 100;
    DBMS_OUTPUT.PUT_LINE('PRIOR element: ' || sparse_arr.prior(100));
END;

PRIOR element: 10
```

3.11.10 TRIM

The `TRIM` method removes an element or elements from the end of a collection. The syntax for the `TRIM` method is:

```
collection.TRIM[ (count) ]
```

collection is the name of a collection.

count is the number of elements removed from the end of the collection. Advanced Server will return an error if *count* is less than 0 or greater than the number of elements in the collection.

The following example demonstrates using the `TRIM` method to remove an element from the end of a collection:

```

DECLARE
    TYPE sparse_arr_typ IS TABLE OF NUMBER;
    sparse_arr      sparse_arr_typ := sparse_arr_typ(-100,-10,0,10,100);
BEGIN
    DBMS_OUTPUT.PUT_LINE('COUNT: ' || sparse_arr.COUNT);
    sparse_arr.TRIM;
    DBMS_OUTPUT.PUT_LINE('COUNT: ' || sparse_arr.COUNT);
END;

COUNT: 5
COUNT: 4

```

COUNT indicates that before the TRIM method, there were 5 elements in the collection; after the TRIM method was invoked, the collection contains 4 elements.

You can also specify the number of elements to remove from the end of the collection with the TRIM method:

```

DECLARE
    TYPE sparse_arr_typ IS TABLE OF NUMBER;
    sparse_arr      sparse_arr_typ := sparse_arr_typ(-100,-10,0,10,100);
    v_results       VARCHAR2(50);
BEGIN
    DBMS_OUTPUT.PUT_LINE('COUNT: ' || sparse_arr.COUNT);
    sparse_arr.TRIM(2);
    DBMS_OUTPUT.PUT_LINE('COUNT: ' || sparse_arr.COUNT);
    FOR i IN sparse_arr.FIRST .. sparse_arr.LAST LOOP
        IF sparse_arr(i) IS NULL THEN
            v_results := v_results || 'NULL ';
        ELSE
            v_results := v_results || sparse_arr(i) || ' ';
        END IF;
    END LOOP;
    DBMS_OUTPUT.PUT_LINE('Results: ' || v_results);
END;

COUNT: 5
COUNT: 3
Results: -100 -10 0

```

COUNT indicates that before the TRIM method, there were 5 elements in the collection; after the TRIM method was invoked, the collection contains 3 elements.

3.12 Working with Collections

Collection operators allow you to transform, query and manipulate the contents of a collection.

3.12.1 TABLE()

Use the `TABLE ()` function to transform the members of an array into a set of rows. The signature is:

```
TABLE (collection_value)
```

Where:

collection_value

collection_value is an expression that evaluates to a value of collection type.

The `TABLE ()` function expands the nested contents of a collection into a table format. You can use the `TABLE ()` function anywhere you use a regular table expression.

The `TABLE ()` function returns a `SETOF ANYELEMENT` (a set of values of any type). For example, if the argument passed to this function is an array of `dates`, `TABLE ()` will return a `SETOF dates`. If the argument passed to this function is an array of `paths`, `TABLE ()` will return a `SETOF paths`.

You can use the `TABLE ()` function to expand the contents of a collection into table form:

```
postgres=# SELECT * FROM TABLE(monthly_balance(445.00, 980.20, 552.00));
monthly_balance
-----
445.00
980.20
552.00
(3 rows)
```

3.12.2 Using the MULTISET UNION Operator

The `MULTISET UNION` operator combines two collections to form a third collection. The signature is:

```
coll_1 MULTISET UNION [ALL | DISTINCT] coll_2
```

coll_1 and *coll_2* specify the names of the collections to combine.

Include the `ALL` keyword to specify that duplicate elements (elements that are present in both `coll_1` and `coll_2`) should be represented in the result, once for each time they are present in the original collections. This is the default behavior of `MULTISET UNION`.

Include the `DISTINCT` keyword to specify that duplicate elements should be included in the result only once.

The following example demonstrates using the `MULTISET UNION` operator to combine two collections (`collection_1` and `collection_2`) into a third collection (`collection_3`):

```

DECLARE
    TYPE int_arr_typ IS TABLE OF NUMBER(2);
    collection_1    int_arr_typ;
    collection_2    int_arr_typ;
    collection_3    int_arr_typ;
    v_results       VARCHAR2(50);
BEGIN
    collection_1 := int_arr_typ(10,20,30);
    collection_2 := int_arr_typ(30,40);
    collection_3 := collection_1 MULTISET UNION ALL collection_2;
    DBMS_OUTPUT.PUT_LINE('COUNT: ' || collection_3.COUNT);
    FOR i IN collection_3.FIRST .. collection_3.LAST LOOP
        IF collection_3(i) IS NULL THEN
            v_results := v_results || 'NULL ';
        ELSE
            v_results := v_results || collection_3(i) || ' ';
        END IF;
    END LOOP;
    DBMS_OUTPUT.PUT_LINE('Results: ' || v_results);
END;

COUNT: 5
Results: 10 20 30 30 40

```

The resulting collection includes one entry for each element in `collection_1` and `collection_2`. If the `DISTINCT` keyword is used, the results are the following:

```

DECLARE
    TYPE int_arr_typ IS TABLE OF NUMBER(2);
    collection_1    int_arr_typ;
    collection_2    int_arr_typ;
    collection_3    int_arr_typ;
    v_results       VARCHAR2(50);
BEGIN
    collection_1 := int_arr_typ(10,20,30);
    collection_2 := int_arr_typ(30,40);
    collection_3 := collection_1 MULTISET UNION DISTINCT collection_2;
    DBMS_OUTPUT.PUT_LINE('COUNT: ' || collection_3.COUNT);
    FOR i IN collection_3.FIRST .. collection_3.LAST LOOP
        IF collection_3(i) IS NULL THEN
            v_results := v_results || 'NULL ';
        ELSE
            v_results := v_results || collection_3(i) || ' ';
        END IF;
    END LOOP;
    DBMS_OUTPUT.PUT_LINE('Results: ' || v_results);

```

```

END;

COUNT: 4
Results: 10 20 30 40

```

The resulting collection includes only those members with distinct values. Note in the following example that the `MULTISET UNION DISTINCT` operator also removes duplicate entries that are stored within the same collection:

```

DECLARE
    TYPE int_arr_typ IS TABLE OF NUMBER(2);
    collection_1    int_arr_typ;
    collection_2    int_arr_typ;
    collection_3    int_arr_typ;
    v_results      VARCHAR2(50);
BEGIN
    collection_1 := int_arr_typ(10,20,30,30);
    collection_2 := int_arr_typ(40,50);
    collection_3 := collection_1 MULTISET UNION DISTINCT collection_2;
    DBMS_OUTPUT.PUT_LINE('COUNT: ' || collection_3.COUNT);
    FOR i IN collection_3.FIRST .. collection_3.LAST LOOP
        IF collection_3(i) IS NULL THEN
            v_results := v_results || 'NULL ';
        ELSE
            v_results := v_results || collection_3(i) || ' ';
        END IF;
    END LOOP;
    DBMS_OUTPUT.PUT_LINE('Results: ' || v_results);
END;

COUNT: 5
Results: 10 20 30 40 50

```

3.12.3 Using the FORALL Statement

Collections can be used to more efficiently process DML commands by passing all the values to be used for repetitive execution of a `DELETE`, `INSERT`, or `UPDATE` command in one pass to the database server rather than re-iteratively invoking the DML command with new values. The DML command to be processed in such a manner is specified with the `FORALL` statement. In addition, one or more collections are given in the DML command where different values are to be substituted each time the command is executed.

```

FORALL index IN lower_bound .. upper_bound
    { insert_stmt | update_stmt | delete_stmt };

```

`index` is the position in the collection given in the `insert_stmt`, `update_stmt`, or `delete_stmt` DML command that iterates from the integer value given as `lower_bound` up to and including `upper_bound`.

Note: If an exception occurs during any iteration of the `FORALL` statement, all updates that occurred since the start of the execution of the `FORALL` statement are automatically

rolled back. This behavior is not compatible with Oracle databases. Oracle allows explicit use of the `COMMIT` or `ROLLBACK` commands to control whether or not to commit or roll back updates that occurred prior to the exception.

The `FORALL` statement creates a loop – each iteration of the loop increments the *index* variable (you typically use the *index* within the loop to select a member of a collection). The number of iterations is controlled by the `lower_bound .. upper_bound` clause. The loop executes once for each integer between the `lower_bound` and `upper_bound` (inclusive) and the index is incremented by one for each iteration. For example:

```
FORALL i IN 2 .. 5
```

Creates a loop that executes four times – in the first iteration, the `index(i)` is set to the value 2; in the second iteration, the index is set to the value 3, and so on. The loop executes for the value 5 and then terminates.

The following example creates a table (`emp_copy`) that is an empty copy of the `emp` table. The example declares a type (`emp_tbl`) that is an array where each element in the array is of composite type, composed of the column definitions used to create the table, `emp`. The example also creates an index on the `emp_tbl` type.

`t_emp` is an associative array, of type `emp_tbl`. The `SELECT` statement uses the `BULK COLLECT INTO` command to populate the `t_emp` array. After the `t_emp` array is populated, the `FORALL` statement iterates through the values (`i`) in the `t_emp` array index and inserts a row for each record into `emp_copy`.

```
CREATE TABLE emp_copy (LIKE emp);

DECLARE

    TYPE emp_tbl IS TABLE OF emp%ROWTYPE INDEX BY BINARY_INTEGER;

    t_emp emp_tbl;

BEGIN
    SELECT * FROM emp BULK COLLECT INTO t_emp;

    FORALL i IN t_emp.FIRST .. t_emp.LAST
        INSERT INTO emp_copy VALUES t_emp(i);

END;
```

The following example uses a `FORALL` statement to update the salary of three employees:

```
DECLARE
    TYPE empno_tbl  IS TABLE OF emp.empno%TYPE INDEX BY BINARY_INTEGER;
    TYPE sal_tbl   IS TABLE OF emp.ename%TYPE INDEX BY BINARY_INTEGER;
    t_empno        EMPNO_TBL;
    t_sal          SAL_TBL;
BEGIN
```

```

t_empno(1) := 9001;
t_sal(1)   := 3350.00;
t_empno(2) := 9002;
t_sal(2)   := 2000.00;
t_empno(3) := 9003;
t_sal(3)   := 4100.00;
FORALL i IN t_empno.FIRST..t_empno.LAST
    UPDATE emp SET sal = t_sal(i) WHERE empno = t_empno(i);
END;

SELECT * FROM emp WHERE empno > 9000;

empno | ename | job | mgr | hiredate | sal | comm | deptno
-----+-----+-----+-----+-----+-----+-----+-----+
9001 | JONES | ANALYST |     |       | 3350.00 |     | 40
9002 | LARSEN | CLERK |     |       | 2000.00 |     | 40
9003 | WILSON | MANAGER |     |       | 4100.00 |     | 40
(3 rows)

```

The following example deletes three employees in a FORALL statement:

```

DECLARE
    TYPE empno_tbl  IS TABLE OF emp.empno%TYPE INDEX BY BINARY_INTEGER;
    t_empno        EMPNO_TBL;
BEGIN
    t_empno(1) := 9001;
    t_empno(2) := 9002;
    t_empno(3) := 9003;
    FORALL i IN t_empno.FIRST..t_empno.LAST
        DELETE FROM emp WHERE empno = t_empno(i);
END;

SELECT * FROM emp WHERE empno > 9000;

empno | ename | job | mgr | hiredate | sal | comm | deptno
-----+-----+-----+-----+-----+-----+-----+-----+
(0 rows)

```

3.12.4 Using the BULK COLLECT Clause

SQL commands that return a result set consisting of a large number of rows may not be operating as efficiently as possible due to the constant context switching that must occur between the database server and the client in order to transfer the entire result set. This inefficiency can be mitigated by using a collection to gather the entire result set in memory which the client can then access. The `BULK COLLECT` clause is used to specify the aggregation of the result set into a collection.

The `BULK COLLECT` clause can be used with the `SELECT INTO`, `FETCH INTO` and `EXECUTE IMMEDIATE` commands, and with the `RETURNING INTO` clause of the `DELETE`, `INSERT`, and `UPDATE` commands. Each of these is illustrated in the following sections.

3.12.4.1 SELECT BULK COLLECT

The `BULK COLLECT` clause can be used with the `SELECT INTO` statement as follows. (Refer to Section [3.4.3](#) for additional information on the `SELECT INTO` statement.)

```
SELECT select_expressions BULK COLLECT INTO collection
[, ...] FROM ...;
```

If a single collection is specified, then `collection` may be a collection of a single field, or it may be a collection of a record type. If more than one collection is specified, then each `collection` must consist of a single field. `select_expressions` must match in number, order, and type-compatibility all fields in the target collections.

The following example shows the use of the `BULK COLLECT` clause where the target collections are associative arrays consisting of a single field.

```
DECLARE
    TYPE empno_tbl      IS TABLE OF emp.empno%TYPE      INDEX BY BINARY_INTEGER;
    TYPE ename_tbl       IS TABLE OF emp.ename%TYPE      INDEX BY BINARY_INTEGER;
    TYPE job_tbl         IS TABLE OF emp.job%TYPE       INDEX BY BINARY_INTEGER;
    TYPE hiredate_tbl   IS TABLE OF emp.hiredate%TYPE   INDEX BY BINARY_INTEGER;
    TYPE sal_tbl         IS TABLE OF emp.sal%TYPE       INDEX BY BINARY_INTEGER;
    TYPE comm_tbl        IS TABLE OF emp.comm%TYPE      INDEX BY BINARY_INTEGER;
    TYPE deptno_tbl     IS TABLE OF emp.deptno%TYPE     INDEX BY BINARY_INTEGER;
    t_empno              EMPNO_TBL;
    t_ename              ENAME_TBL;
    t_job                JOB_TBL;
    t_hiredate           HIREDATE_TBL;
    t_sal                SAL_TBL;
    t_comm               COMM_TBL;
    t_deptno             DEPTNO_TBL;
BEGIN
    SELECT empno, ename, job, hiredate, sal, comm, deptno BULK COLLECT
        INTO t_empno, t_ename, t_job, t_hiredate, t_sal, t_comm, t_deptno
        FROM emp;
    DBMS_OUTPUT.PUT_LINE('EMPNO  ENAME      JOB          HIREDATE      ' || |
                           'SAL      ' || 'COMM      DEPTNO');
    DBMS_OUTPUT.PUT_LINE('----- ----- ----- ----- ----- ' || |
                           '----- ' || '----- ' || '----- ');
    FOR i IN 1..t_empno.COUNT LOOP
        DBMS_OUTPUT.PUT_LINE(t_empno(i) || ' ' || |
                             RPAD(t_ename(i),8) || ' ' || |
                             RPAD(t_job(i),10) || ' ' || |
                             TO_CHAR(t_hiredate(i), 'DD-MON-YY') || ' ' || |
                             TO_CHAR(t_sal(i), '99,999.99') || ' ' || |
                             TO_CHAR(NVL(t_comm(i),0), '99,999.99') || ' ' || |
                             t_deptno(i));
    END LOOP;
END;
```

EMPNO	ENAME	JOB	HIREDATE	SAL	COMM	DEPTNO
7369	SMITH	CLERK	17-DEC-80	800.00	.00	20
7499	ALLEN	SALESMAN	20-FEB-81	1,600.00	300.00	30
7521	WARD	SALESMAN	22-FEB-81	1,250.00	500.00	30
7566	JONES	MANAGER	02-APR-81	2,975.00	.00	20
7654	MARTIN	SALESMAN	28-SEP-81	1,250.00	1,400.00	30

7698	BLAKE	MANAGER	01-MAY-81	2,850.00	.00	30
7782	CLARK	MANAGER	09-JUN-81	2,450.00	.00	10
7788	SCOTT	ANALYST	19-APR-87	3,000.00	.00	20
7839	KING	PRESIDENT	17-NOV-81	5,000.00	.00	10
7844	TURNER	SALESMAN	08-SEP-81	1,500.00	.00	30
7876	ADAMS	CLERK	23-MAY-87	1,100.00	.00	20
7900	JAMES	CLERK	03-DEC-81	950.00	.00	30
7902	FORD	ANALYST	03-DEC-81	3,000.00	.00	20
7934	MILLER	CLERK	23-JAN-82	1,300.00	.00	10

The following example produces the same result, but uses an associative array on a record type defined with the %ROWTYPE attribute.

```

DECLARE
    TYPE emp_tbl IS TABLE OF emp%ROWTYPE INDEX BY BINARY_INTEGER;
    t_emp          EMP_TBL;
BEGIN
    SELECT * BULK COLLECT INTO t_emp FROM emp;
    DBMS_OUTPUT.PUT_LINE('EMPNO  ENAME      JOB          HIREDATE      ');
    DBMS_OUTPUT.PUT_LINE('-----  -----      -----          -----      ');
    FOR i IN 1..t_emp.COUNT LOOP
        DBMS_OUTPUT.PUT_LINE(t_emp(i).empno || ' ' ||
            RPAD(t_emp(i).ename,8) || ' ' ||
            RPAD(t_emp(i).job,10) || ' ' ||
            TO_CHAR(t_emp(i).hiredate,'DD-MON-YY') || ' ' ||
            TO_CHAR(t_emp(i).sal,'99,999.99') || ' ' ||
            TO_CHAR(NVL(t_emp(i).comm,0),'99,999.99') || ' ' ||
            t_emp(i).deptno);
    END LOOP;
END;

```

EMPNO	ENAME	JOB	HIREDATE	SAL	COMM	DEPTNO
7369	SMITH	CLERK	17-DEC-80	800.00	.00	20
7499	ALLEN	SALESMAN	20-FEB-81	1,600.00	300.00	30
7521	WARD	SALESMAN	22-FEB-81	1,250.00	500.00	30
7566	JONES	MANAGER	02-APR-81	2,975.00	.00	20
7654	MARTIN	SALESMAN	28-SEP-81	1,250.00	1,400.00	30
7698	BLAKE	MANAGER	01-MAY-81	2,850.00	.00	30
7782	CLARK	MANAGER	09-JUN-81	2,450.00	.00	10
7788	SCOTT	ANALYST	19-APR-87	3,000.00	.00	20
7839	KING	PRESIDENT	17-NOV-81	5,000.00	.00	10
7844	TURNER	SALESMAN	08-SEP-81	1,500.00	.00	30
7876	ADAMS	CLERK	23-MAY-87	1,100.00	.00	20
7900	JAMES	CLERK	03-DEC-81	950.00	.00	30
7902	FORD	ANALYST	03-DEC-81	3,000.00	.00	20
7934	MILLER	CLERK	23-JAN-82	1,300.00	.00	10

3.12.4.2 FETCH BULK COLLECT

The BULK COLLECT clause can be used with a FETCH statement. (See Section 3.8.3 for information on the FETCH statement.) Instead of returning a single row at a time from the result set, the FETCH BULK COLLECT will return all rows at once from the result set into the specified collection unless restricted by the LIMIT clause.

```
FETCH name BULK COLLECT INTO collection [, ...] [ LIMIT n] ;
```

If a single collection is specified, then *collection* may be a collection of a single field, or it may be a collection of a record type. If more than one collection is specified, then each *collection* must consist of a single field. The expressions in the SELECT list of the cursor identified by *name* must match in number, order, and type-compatibility all fields in the target collections. If LIMIT *n* is specified, the number of rows returned into the collection on each FETCH will not exceed *n*.

The following example uses the FETCH BULK COLLECT statement to retrieve rows into an associative array.

```
DECLARE
    TYPE emp_tbl IS TABLE OF emp%ROWTYPE INDEX BY BINARY_INTEGER;
    t_emp          EMP_TBL;
    CURSOR emp_cur IS SELECT * FROM emp;
BEGIN
    OPEN emp_cur;
    FETCH emp_cur BULK COLLECT INTO t_emp;
    CLOSE emp_cur;
    DBMS_OUTPUT.PUT_LINE('EMPNO    ENAME      JOB           HIREDATE      ' || |
                         'SAL        ' || 'COMM      DEPTNO');
    DBMS_OUTPUT.PUT_LINE('-----  -----  -----  -----  -----  ' || |
                         '-----  ' || '-----  ' || '-----');
    FOR i IN 1..t_emp.COUNT LOOP
        DBMS_OUTPUT.PUT_LINE(t_emp(i).empno || ' ' || |
                             RPAD(t_emp(i).ename,8) || ' ' || |
                             RPAD(t_emp(i).job,10) || ' ' || |
                             TO_CHAR(t_emp(i).hiredate,'DD-MON-YY') || ' ' || |
                             TO_CHAR(t_emp(i).sal,'99,999.99') || ' ' || |
                             TO_CHAR(NVL(t_emp(i).comm,0),'99,999.99') || ' ' || |
                             t_emp(i).deptno);
    END LOOP;
END;
```

EMPNO	ENAME	JOB	HIREDATE	SAL	COMM	DEPTNO
7369	SMITH	CLERK	17-DEC-80	800.00	.00	20
7499	ALLEN	SALESMAN	20-FEB-81	1,600.00	300.00	30
7521	WARD	SALESMAN	22-FEB-81	1,250.00	500.00	30
7566	JONES	MANAGER	02-APR-81	2,975.00	.00	20
7654	MARTIN	SALESMAN	28-SEP-81	1,250.00	1,400.00	30
7698	BLAKE	MANAGER	01-MAY-81	2,850.00	.00	30
7782	CLARK	MANAGER	09-JUN-81	2,450.00	.00	10
7788	SCOTT	ANALYST	19-APR-87	3,000.00	.00	20
7839	KING	PRESIDENT	17-NOV-81	5,000.00	.00	10
7844	TURNER	SALESMAN	08-SEP-81	1,500.00	.00	30
7876	ADAMS	CLERK	23-MAY-87	1,100.00	.00	20
7900	JAMES	CLERK	03-DEC-81	950.00	.00	30
7902	FORD	ANALYST	03-DEC-81	3,000.00	.00	20
7934	MILLER	CLERK	23-JAN-82	1,300.00	.00	10

3.12.4.3 EXECUTE IMMEDIATE BULK COLLECT

The `BULK COLLECT` clause can be used with a `EXECUTE IMMEDIATE` statement to specify a collection to receive the returned rows.

```
EXECUTE IMMEDIATE 'sql_expression;'
    BULK COLLECT INTO collection [, ...]
    [USING {[bind_type] bind_argument} [, ...}}];
```

`collection` specifies the name of a collection.

`bind_type` specifies the parameter mode of the `bind_argument`.

- A `bind_type` of `IN` specifies that the `bind_argument` contains a value that is passed to the `sql_expression`.
- A `bind_type` of `OUT` specifies that the `bind_argument` receives a value from the `sql_expression`.
- A `bind_type` of `IN OUT` specifies that the `bind_argument` is passed to `sql_expression`, and then stores the value returned by `sql_expression`.

`bind_argument` specifies a parameter that contains a value that is either passed to the `sql_expression` (specified with a `bind_type` of `IN`), or that receives a value from the `sql_expression` (specified with a `bind_type` of `OUT`), or both (specified with a `bind_type` of `IN OUT`).

If a single collection is specified, then `collection` may be a collection of a single field, or a collection of a record type; if more than one collection is specified, each `collection` must consist of a single field.

3.12.4.4 RETURNING BULK COLLECT

The `BULK COLLECT` clause can be added to the `RETURNING INTO` clause of a `DELETE`, `INSERT`, or `UPDATE` command. (See Section 3.4.7 for information on the `RETURNING INTO` clause.)

```
{ insert | update | delete }
  RETURNING { * | expr_1 [, expr_2 ] ... }
    BULK COLLECT INTO collection [, ...];
```

`insert`, `update`, and `delete` are the `INSERT`, `UPDATE`, and `DELETE` commands as described in Sections 3.4.4, 3.4.5, and 3.4.6, respectively. If a single collection is specified, then `collection` may be a collection of a single field, or it may be a collection of a record type. If more than one collection is specified, then each

collection must consist of a single field. The expressions following the `RETURNING` keyword must match in number, order, and type-compatibility all fields in the target collections. If `*` is specified, then all columns in the affected table are returned. (Note that the use of `*` is an Advanced Server extension and is not compatible with Oracle databases.)

The `clerkemp` table created by copying the `emp` table is used in the remaining examples in this section as shown below.

```
CREATE TABLE clerkemp AS SELECT * FROM emp WHERE job = 'CLERK';

SELECT * FROM clerkemp;

empno | ename | job | mgr |      hiredate      |    sal    | comm | deptno
-----+-----+-----+-----+-----+-----+-----+-----+
-
7369 | SMITH | CLERK | 7902 | 17-DEC-80 00:00:00 | 800.00 |   | 20
7876 | ADAMS | CLERK | 7788 | 23-MAY-87 00:00:00 | 1100.00 |   | 20
7900 | JAMES | CLERK | 7698 | 03-DEC-81 00:00:00 | 950.00 |   | 30
7934 | MILLER | CLERK | 7782 | 23-JAN-82 00:00:00 | 1300.00 |   | 10
(4 rows)
```

The following example increases everyone's salary by 1.5, stores the employees' numbers, names, and new salaries in three associative arrays, and finally, displays the contents of these arrays.

```
DECLARE
  TYPE empno_tbl IS TABLE OF emp.empno%TYPE INDEX BY BINARY_INTEGER;
  TYPE ename_tbl IS TABLE OF emp.ename%TYPE INDEX BY BINARY_INTEGER;
  TYPE sal_tbl IS TABLE OF emp.sal%TYPE INDEX BY BINARY_INTEGER;
  t_empno      EMPNO_TBL;
  t_ename      ENAME_TBL;
  t_sal        SAL_TBL;
BEGIN
  UPDATE clerkemp SET sal = sal * 1.5 RETURNING empno, ename, sal
    BULK COLLECT INTO t_empno, t_ename, t_sal;
  DBMS_OUTPUT.PUT_LINE('EMPNO  ENAME      SAL      ');
  DBMS_OUTPUT.PUT_LINE('----  -----      ----      ');
  FOR i IN 1..t_empno.COUNT LOOP
    DBMS_OUTPUT.PUT_LINE(t_empno(i) || ' ' || RPAD(t_ename(i),8) ||
    ' ' || TO_CHAR(t_sal(i), '99,999.99'));
  END LOOP;
END;

EMPNO  ENAME      SAL
-----  -----      -----
7369   SMITH     1,200.00
7876   ADAMS     1,650.00
7900   JAMES     1,425.00
7934   MILLER    1,950.00
```

The following example performs the same functionality as the previous example, but uses a single collection defined with a record type to store the employees' numbers, names, and new salaries.

```
DECLARE
```

```

TYPE emp_rec IS RECORD (
    empno    emp.empno%TYPE,
    ename    emp.ename%TYPE,
    sal      emp.sal%TYPE
);
TYPE emp_tbl IS TABLE OF emp_rec INDEX BY BINARY_INTEGER;
t_emp          EMP_TBL;
BEGIN
    UPDATE clerkemp SET sal = sal * 1.5 RETURNING empno, ename, sal
        BULK COLLECT INTO t_emp;
    DBMS_OUTPUT.PUT_LINE('EMPNO  ENAME      SAL      ');
    DBMS_OUTPUT.PUT_LINE('-----  -----  -----  ');
    FOR i IN 1..t_emp.COUNT LOOP
        DBMS_OUTPUT.PUT_LINE(t_emp(i).empno || ' ' ||
            RPAD(t_emp(i).ename,8) || ' ' ||
            TO_CHAR(t_emp(i).sal,'99,999.99'));
    END LOOP;
END;

```

EMPNO	ENAME	SAL
7369	SMITH	1,200.00
7876	ADAMS	1,650.00
7900	JAMES	1,425.00
7934	MILLER	1,950.00

The following example deletes all rows from the `clerkemp` table, and returns information on the deleted rows into an associative array, which is then displayed.

```

DECLARE
    TYPE emp_rec IS RECORD (
        empno    emp.empno%TYPE,
        ename    emp.ename%TYPE,
        job      emp.job%TYPE,
        hiredate  emp.hiredate%TYPE,
        sal      emp.sal%TYPE,
        comm     emp.comm%TYPE,
        deptno   emp.deptno%TYPE
    );
    TYPE emp_tbl IS TABLE OF emp_rec INDEX BY BINARY_INTEGER;
    r_emp          EMP_TBL;
BEGIN
    DELETE FROM clerkemp RETURNING empno, ename, job, hiredate, sal,
        comm, deptno BULK COLLECT INTO r_emp;
    DBMS_OUTPUT.PUT_LINE('EMPNO  ENAME      JOB      HIREDATE      ' ||
        'SAL      ' || 'COMM      DEPTNO');
    DBMS_OUTPUT.PUT_LINE('-----  -----  -----  -----  -----  ' ||
        '-----  ' || '-----  -----  ');
    FOR i IN 1..r_emp.COUNT LOOP
        DBMS_OUTPUT.PUT_LINE(r_emp(i).empno || ' ' ||
            RPAD(r_emp(i).ename,8) || ' ' ||
            RPAD(r_emp(i).job,10) || ' ' ||
            TO_CHAR(r_emp(i).hiredate,'DD-MON-YY') || ' ' ||
            TO_CHAR(r_emp(i).sal,'99,999.99') || ' ' ||
            TO_CHAR(NVL(r_emp(i).comm,0),'99,999.99') || ' ' ||
            r_emp(i).deptno);
    END LOOP;
END;

```

EMPNO	ENAME	JOB	HIREDATE	SAL	COMM	DEPTNO
7369	SMITH	CLERK	17-DEC-80	1,200.00	.00	20

7876	ADAMS	CLERK	23-MAY-87	1,650.00	.00	20
7900	JAMES	CLERK	03-DEC-81	1,425.00	.00	30
7934	MILLER	CLERK	23-JAN-82	1,950.00	.00	10

3.13 Errors and Messages

Use the `DBMS_OUTPUT.PUT_LINE` statement to report messages.

```
DBMS_OUTPUT.PUT_LINE ( message );
```

message is any expression evaluating to a string.

This example displays the message on the user's output display:

```
DBMS_OUTPUT.PUT_LINE ('My name is John');
```

The special variables `SQLCODE` and `SQLERRM` contain a numeric code and a text message, respectively, that describe the outcome of the last SQL command issued. If any other error occurs in the programs such as division by zero, these variables contain information pertaining to the error.

4 Triggers

This chapter describes *triggers* in Advanced Server. As with procedures and functions, triggers are written in the SPL language.

4.1 Overview

A trigger is a named SPL code block that is associated with a table and stored in the database. When a specified event occurs on the associated table, the SPL code block is executed. The trigger is said to be *fired* when the code block is executed.

The event that causes a trigger to fire can be any combination of an insert, update, or deletion carried out on the table, either directly or indirectly. If the table is the object of a SQL `INSERT`, `UPDATE`, or `DELETE` command the trigger is directly fired assuming that the corresponding insert, update, or deletion event is defined as a *triggering event*. The events that fire the trigger are defined in the `CREATE TRIGGER` command.

A trigger can be fired indirectly if a triggering event occurs on the table as a result of an event initiated on another table. For example, if a trigger is defined on a table containing a foreign key defined with the `ON DELETE CASCADE` clause and a row in the parent table is deleted, all children of the parent would be deleted as well. If deletion is a triggering event on the child table, deletion of the children will cause the trigger to fire.

4.2 Types of Triggers

Advanced Server supports both *row-level* and *statement-level* triggers. A row-level trigger fires once for each row that is affected by a triggering event. For example, if deletion is defined as a triggering event on a table and a single `DELETE` command is issued that deletes five rows from the table, then the trigger will fire five times, once for each row.

In contrast, a statement-level trigger fires once per triggering statement regardless of the number of rows affected by the triggering event. In the prior example of a single `DELETE` command deleting five rows, a statement-level trigger would fire only once.

The sequence of actions can be defined regarding whether the trigger code block is executed before or after the triggering statement, itself, in the case of statement-level triggers; or before or after each row is affected by the triggering statement in the case of row-level triggers.

In a *before* row-level trigger, the trigger code block is executed before the triggering action is carried out on each affected row. In a *before* statement-level trigger, the trigger code block is executed before the action of the triggering statement is carried out.

In an *after* row-level trigger, the trigger code block is executed after the triggering action is carried out on each affected row. In an *after* statement-level trigger, the trigger code block is executed after the action of the triggering statement is carried out.

4.3 Creating Triggers

The `CREATE TRIGGER` command defines and names a trigger that will be stored in the database.

Name

`CREATE TRIGGER` -- define a new trigger

Synopsis

```
CREATE [ OR REPLACE ] TRIGGER name
  { BEFORE | AFTER | INSTEAD OF }
  { INSERT | UPDATE | DELETE }
    [ OR { INSERT | UPDATE | DELETE } ] [, ...]
    ON table
  [ REFERENCING { OLD AS old | NEW AS new } ...]
  [ FOR EACH ROW ]
  [ WHEN condition ]
  [ DECLARE
      declaration; [, ...] ]
  BEGIN
    statement; [, ...]
  [ EXCEPTION
    { WHEN exception [ OR exception ] [...] THEN
        statement; [, ...] } [, ...]
  ]
  END
```

Description

`CREATE TRIGGER` defines a new trigger. `CREATE OR REPLACE TRIGGER` will either create a new trigger, or replace an existing definition.

If you are using the `CREATE TRIGGER` keywords to create a new trigger, the name of the new trigger must not match any existing trigger defined on the same table. New triggers will be created in the same schema as the table on which the triggering event is defined.

If you are updating the definition of an existing trigger, use the `CREATE OR REPLACE TRIGGER` keywords.

When you use syntax compatible with Oracle databases to create a trigger, the trigger runs as a `SECURITY DEFINER` function.

Parameters

name

The name of the trigger to create.

BEFORE | AFTER

Determines whether the trigger is fired before or after the triggering event.

INSERT | UPDATE | DELETE

Defines the triggering event.

table

The name of the table on which the triggering event occurs.

condition

condition is a Boolean expression that determines if the trigger will actually be executed; if *condition* evaluates to TRUE, the trigger will fire.

If the trigger definition includes the FOR EACH ROW keywords, the WHEN clause can refer to columns of the old and/or new row values by writing OLD.*column_name* or NEW.*column_name* respectively. INSERT triggers cannot refer to OLD and DELETE triggers cannot refer to NEW.

If the trigger includes the INSTEAD OF keywords, it may not include a WHEN clause.

WHEN clauses cannot contain subqueries.

REFERENCING { OLD AS *old* | NEW AS *new* } ...

REFERENCING clause to reference old rows and new rows, but restricted in that *old* may only be replaced by an identifier named *old* or any equivalent that is saved in all lowercase (for example, REFERENCING OLD AS *old*, REFERENCING OLD AS OLD, or REFERENCING OLD AS "old"). Also, *new* may only be replaced by an identifier named *new* or any equivalent that is saved in all lowercase (for example, REFERENCING NEW AS *new*, REFERENCING NEW AS NEW, or REFERENCING NEW AS "new").

Either one, or both phrases OLD AS *old* and NEW AS *new* may be specified in the REFERENCING clause (for example, REFERENCING NEW AS New OLD AS *old*).

See Section [3.4](#) for information on how these identifiers are used as pseudo-record names to reference old rows and new rows.

This clause is not compatible with Oracle databases in that identifiers other than `old` or `new` may not be used.

`FOR EACH ROW`

Determines whether the trigger should be fired once for every row affected by the triggering event, or just once per SQL statement. If specified, the trigger is fired once for every affected row (row-level trigger), otherwise the trigger is a statement-level trigger.

declaration

A variable, type, REF CURSOR, or subprogram declaration. If subprogram declarations are included, they must be declared after all other variable, type, and REF CURSOR declarations.

statement

An SPL program statement. Note that a `DECLARE` – `BEGIN` – `END` block is considered an SPL statement unto itself. Thus, the trigger body may contain nested blocks.

exception

An exception condition name such as `NO_DATA_FOUND`, `OTHERS`, etc.

4.4 Trigger Variables

In the trigger code block, several special variables are available for use.

NEW

`NEW` is a pseudo-record name that refers to the new table row for insert and update operations in row-level triggers. This variable is not applicable in statement-level triggers and in delete operations of row-level triggers.

Its usage is `:NEW.column` where `column` is the name of a column in the table on which the trigger is defined.

The initial content of `:NEW.column` is the value in the named column of the new row to be inserted or of the new row that is to replace the old one when used in a before row-level trigger. When used in an after row-level trigger, this value has already been stored in the table since the action has already occurred on the affected row.

In the trigger code block, `:NEW.column` can be used like any other variable. If a value is assigned to `:NEW.column`, in the code block of a before row-level trigger, the assigned value will be used in the new inserted or updated row.

OLD

`OLD` is a pseudo-record name that refers to the old table row for update and delete operations in row-level triggers. This variable is not applicable in statement-level triggers and in insert operations of row-level triggers.

Its usage is `:OLD.column` where `column` is the name of a column in the table on which the trigger is defined.

The initial content of `:OLD.column` is the value in the named column of the row to be deleted or of the old row that is to be replaced by the new one when used in a before row-level trigger. When used in an after row-level trigger, this value is no longer stored in the table since the action has already occurred on the affected row.

In the trigger code block, `:OLD.column` can be used like any other variable. Assigning a value to `:OLD.column`, has no effect on the action of the trigger.

INSERTING

`INSERTING` is a conditional expression that returns `TRUE` if an insert operation fired the trigger, otherwise it returns `FALSE`.

UPDATING

UPDATING is a conditional expression that returns TRUE if an update operation fired the trigger, otherwise it returns FALSE.

DELETING

DELETING is a conditional expression that returns TRUE if a delete operation fired the trigger, otherwise it returns FALSE.

4.5 Transactions and Exceptions

A trigger is always executed as part of the same transaction within which the triggering statement is executing. When no exceptions occur within the trigger code block, the effects of any DML commands within the trigger are committed if and only if the transaction containing the triggering statement is committed. Therefore, if the transaction is rolled back, the effects of any DML commands within the trigger are also rolled back.

If an exception does occur within the trigger code block, but it is caught and handled in an exception section, the effects of any DML commands within the trigger are still rolled back nonetheless. The triggering statement itself, however, is not rolled back unless the application forces a roll back of the encapsulating transaction.

If an unhandled exception occurs within the trigger code block, the transaction that encapsulates the trigger is aborted and rolled back. Therefore the effects of any DML commands within the trigger and the triggering statement, itself are all rolled back.

4.6 Trigger Examples

The following sections illustrate an example of each type of trigger.

4.6.1 Before Statement-Level Trigger

The following is an example of a simple before statement-level trigger that displays a message prior to an insert operation on the `emp` table.

```
CREATE OR REPLACE TRIGGER emp_alert_trig
  BEFORE INSERT ON emp
BEGIN
  DBMS_OUTPUT.PUT_LINE('New employees are about to be added');
END;
```

The following `INSERT` is constructed so that several new rows are inserted upon a single execution of the command. For each row that has an employee id between 7900 and 7999, a new row is inserted with an employee id incremented by 1000. The following are the results of executing the command when three new rows are inserted.

```
INSERT INTO emp (empno, ename, deptno) SELECT empno + 1000, ename, 40
  FROM emp WHERE empno BETWEEN 7900 AND 7999;
New employees are about to be added

SELECT empno, ename, deptno FROM emp WHERE empno BETWEEN 8900 AND 8999;

  EMPNO ENAME          DEPTNO
----- -----
  8900 JAMES            40
  8902 FORD             40
  8934 MILLER           40
```

The message, New employees are about to be added, is displayed once by the firing of the trigger even though the result is the addition of three new rows.

4.6.2 After Statement-Level Trigger

The following is an example of an after statement-level trigger. Whenever an insert, update, or delete operation occurs on the `emp` table, a row is added to the `empauditlog` table recording the date, user, and action.

```

CREATE TABLE empauditlog (
    audit_date      DATE,
    audit_user      VARCHAR2(20),
    audit_desc      VARCHAR2(20)
);
CREATE OR REPLACE TRIGGER emp_audit_trig
    AFTER INSERT OR UPDATE OR DELETE ON emp
DECLARE
    v_action        VARCHAR2(20);
BEGIN
    IF INSERTING THEN
        v_action := 'Added employee(s)';
    ELSIF UPDATING THEN
        v_action := 'Updated employee(s)';
    ELSIF DELETING THEN
        v_action := 'Deleted employee(s)';
    END IF;
    INSERT INTO empauditlog VALUES (SYSDATE, USER,
        v_action);
END;

```

In the following sequence of commands, two rows are inserted into the `emp` table using two `INSERT` commands. The `sal` and `comm` columns of both rows are updated with one `UPDATE` command. Finally, both rows are deleted with one `DELETE` command.

```

INSERT INTO emp VALUES (9001, 'SMITH', 'ANALYST', 7782, SYSDATE, NULL, NULL, 10);
INSERT INTO emp VALUES (9002, 'JONES', 'CLERK', 7782, SYSDATE, NULL, NULL, 10);
UPDATE emp SET sal = 4000.00, comm = 1200.00 WHERE empno IN (9001, 9002);
DELETE FROM emp WHERE empno IN (9001, 9002);

SELECT TO_CHAR(AUDIT_DATE, 'DD-MON-YY HH24:MI:SS') AS "AUDIT DATE",
    audit_user, audit_desc FROM empauditlog ORDER BY 1 ASC;

AUDIT_DATE          AUDIT_USER          AUDIT_DESC
-----              -----              -----
31-MAR-05 14:59:48 SYSTEM             Added employee(s)
31-MAR-05 15:00:07 SYSTEM             Added employee(s)
31-MAR-05 15:00:19 SYSTEM             Updated employee(s)
31-MAR-05 15:00:34 SYSTEM             Deleted employee(s)

```

The contents of the `empauditlog` table show how many times the trigger was fired - once each for the two inserts, once for the update (even though two rows were changed) and once for the deletion (even though two rows were deleted).

4.6.3 Before Row-Level Trigger

The following example is a before row-level trigger that calculates the commission of every new employee belonging to department 30 that is inserted into the `emp` table.

```
CREATE OR REPLACE TRIGGER emp_comm_trig
  BEFORE INSERT ON emp
  FOR EACH ROW
BEGIN
  IF :NEW.deptno = 30 THEN
    :NEW.comm := :NEW.sal * .4;
  END IF;
END;
```

The listing following the addition of the two employees shows that the trigger computed their commissions and inserted it as part of the new employee rows.

```
INSERT INTO emp VALUES (9005,'ROBERS','SALESMAN',7782,SYSDATE,3000.00,NULL,30);
INSERT INTO emp VALUES (9006,'ALLEN','SALESMAN',7782,SYSDATE,4500.00,NULL,30);
SELECT * FROM emp WHERE empno IN (9005, 9006);

```

EMPNO	ENAME	JOB	MGR	HIREDATE	SAL	COMM	DEPTNO
9005	ROBERS	SALESMAN	7782	01-APR-05	3000	1200	30
9006	ALLEN	SALESMAN	7782	01-APR-05	4500	1800	30

4.6.4 After Row-Level Trigger

The following example is an after row-level trigger. When a new employee row is inserted, the trigger adds a new row to the `jobhist` table for that employee. When an existing employee is updated, the trigger sets the `enddate` column of the latest `jobhist` row (assumed to be the one with a null `enddate`) to the current date and inserts a new `jobhist` row with the employee's new information.

Finally, trigger adds a row to the `empchglog` table with a description of the action.

```
CREATE TABLE empchglog (
  chg_date        DATE,
  chg_desc        VARCHAR2(30)
);
CREATE OR REPLACE TRIGGER emp_chg_trig
  AFTER INSERT OR UPDATE OR DELETE ON emp
  FOR EACH ROW
DECLARE
  v_empno         emp.empno%TYPE;
  v_deptno        emp.deptno%TYPE;
  v_dname         dept.dname%TYPE;
  v_action        VARCHAR2(7);
  v_chgdesc       jobhist.chgdesc%TYPE;
BEGIN
  IF INSERTING THEN
    v_action := 'Added';
    v_empno := :NEW.empno;
    v_deptno := :NEW.deptno;
```

```

    INSERT INTO jobhist VALUES (:NEW.empno, SYSDATE, NULL,
                                :NEW.job, :NEW.sal, :NEW.comm, :NEW.deptno, 'New Hire');
ELSIF UPDATING THEN
    v_action := 'Updated';
    v_empno := :NEW.empno;
    v_deptno := :NEW.deptno;
    v_chgdesc := '';
    IF NVL(:OLD.ename, '-null-') != NVL(:NEW.ename, '-null-') THEN
        v_chgdesc := v_chgdesc || 'name, ';
    END IF;
    IF NVL(:OLD.job, '-null-') != NVL(:NEW.job, '-null-') THEN
        v_chgdesc := v_chgdesc || 'job, ';
    END IF;
    IF NVL(:OLD.sal, -1) != NVL(:NEW.sal, -1) THEN
        v_chgdesc := v_chgdesc || 'salary, ';
    END IF;
    IF NVL(:OLD.comm, -1) != NVL(:NEW.comm, -1) THEN
        v_chgdesc := v_chgdesc || 'commission, ';
    END IF;
    IF NVL(:OLD.deptno, -1) != NVL(:NEW.deptno, -1) THEN
        v_chgdesc := v_chgdesc || 'department, ';
    END IF;
    v_chgdesc := 'Changed ' || RTRIM(v_chgdesc, ', ');
    UPDATE jobhist SET enddate = SYSDATE WHERE empno = :OLD.empno
        AND enddate IS NULL;
    INSERT INTO jobhist VALUES (:NEW.empno, SYSDATE, NULL,
                                :NEW.job, :NEW.sal, :NEW.comm, :NEW.deptno, v_chgdesc);
ELSIF DELETING THEN
    v_action := 'Deleted';
    v_empno := :OLD.empno;
    v_deptno := :OLD.deptno;
END IF;

    INSERT INTO empchglog VALUES (SYSDATE,
                                  v_action || ' employee # ' || v_empno);
END;

```

In the first sequence of commands shown below, two employees are added using two separate `INSERT` commands and then both are updated using a single `UPDATE` command. The contents of the `jobhist` table shows the action of the trigger for each affected row - two new hire entries for the two new employees and two changed commission records for the updated commissions on the two employees. The `empchglog` table also shows the trigger was fired a total of four times, once for each action on the two rows.

```

INSERT INTO emp VALUES (9003,'PETERS','ANALYST',7782,SYSDATE,5000.00,NULL,40);

INSERT INTO emp VALUES (9004,'AIKENS','ANALYST',7782,SYSDATE,4500.00,NULL,40);

UPDATE emp SET comm = sal * 1.1 WHERE empno IN (9003, 9004);

SELECT * FROM jobhist WHERE empno IN (9003, 9004);

    EMPNO STARTDATE ENDDATE      JOB          SAL      COMM      DEPTNO CHGDESC
-----  -----  -----  -----  -----
    9003 31-MAR-05 31-MAR-05 ANALYST      5000
          40 New Hire
    9004 31-MAR-05 31-MAR-05 ANALYST      4500
          40 New Hire
    9003 31-MAR-05           ANALYST      5000      5500      40 Changed
commission
    9004 31-MAR-05           ANALYST      4500      4950      40 Changed
commission

SELECT * FROM empchglog;

```

```
CHG_DATE CHG_DESC
-----
31-MAR-05 Added employee # 9003
31-MAR-05 Added employee # 9004
31-MAR-05 Updated employee # 9003
31-MAR-05 Updated employee # 9004
```

Finally, both employees are deleted with a single `DELETE` command. The `empchglog` table now shows the trigger was fired twice, once for each deleted employee.

```
DELETE FROM emp WHERE empno IN (9003, 9004);

SELECT * FROM empchglog;

CHG_DATE CHG_DESC
-----
31-MAR-05 Added employee # 9003
31-MAR-05 Added employee # 9004
31-MAR-05 Updated employee # 9003
31-MAR-05 Updated employee # 9004
31-MAR-05 Deleted employee # 9003
31-MAR-05 Deleted employee # 9004
```

5 Packages

Advanced Server provides a collection of packages that provide compatibility with Oracle packages.

A *package* is a named collection of functions, procedures, variables, cursors, user-defined record types, and records that are referenced using a common qualifier – the package identifier. Packages have the following characteristics:

- Packages provide a convenient means of organizing the functions and procedures that perform a related purpose. Permission to use the package functions and procedures is dependent upon one privilege granted to the entire package. All of the package programs must be referenced with a common name.
- Certain functions, procedures, variables, types, etc. in the package can be declared as *public*. Public entities are visible and can be referenced by other programs that are given `EXECUTE` privilege on the package. For public functions and procedures, only their signatures are visible - the program names, parameters if any, and return types of functions. The SPL code of these functions and procedures is not accessible to others, therefore applications that utilize a package are dependent only upon the information available in the signature – not in the procedural logic itself.
- Other functions, procedures, variables, types, etc. in the package can be declared as *private*. Private entities can be referenced and used by function and procedures within the package, but not by other external applications. Private entities are for use only by programs within the package.
- Function and procedure names can be overloaded within a package. One or more functions/procedures can be defined with the same name, but with different signatures. This provides the capability to create identically named programs that perform the same job, but on different types of input.

For more information about the package support provided by Advanced Server, please see the *Database Compatibility for Oracle Developers Built-in Package Guide*, available at:

<https://www.enterprisedb.com/resources/product-documentation>

For a list of built-in packages, see the Table of Contents, beginning with Chapter 3 "Built-In Packages" of the *Database Compatibility for Oracle Developers Built-in Package Guide*.

6 Object Types and Objects

This chapter discusses how object-oriented programming techniques can be exploited in SPL. Object-oriented programming as seen in programming languages such as Java and C++ centers on the concept of objects. An *object* is a representation of a real-world entity such as a person, place, or thing. The generic description or definition of a particular object such as a person for example, is called an *object type*. Specific people such as “Joe” or “Sally” are said to be *objects of object type*, person, or equivalently, *instances* of the object type, person, or simply, person objects.

Note: The terms “database objects” and “objects” that have been used in this document up to this point should not be confused with an object type and object as used in this chapter. The previous usage of these terms relates to the entities that can be created in a database such as tables, views, indexes, users, etc. Within the context of this chapter, object type and object refer to specific data structures supported by the SPL programming language to implement object-oriented concepts.

Note: In Oracle, the term *abstract data type* (ADT) is used to describe object types in PL/SQL. The SPL implementation of object types is intended to be compatible with Oracle abstract data types.

Note: Advanced Server has not yet implemented support for some features of object-oriented programming languages. This chapter documents only those features that have been implemented.

6.1 Basic Object Concepts

An object type is a description or definition of some entity. This definition of an object type is characterized by two components:

- *Attributes* – fields that describe particular characteristics of an object instance. For a person object, examples might be name, address, gender, date of birth, height, weight, eye color, occupation, etc.
- *Methods* – programs that perform some type of function or operation on, or related to an object. For a person object, examples might be calculating the person’s age, displaying the person’s attributes, changing the values assigned to the person’s attributes, etc.

The following sections elaborate on some basic object concepts.

6.1.1 Attributes

Every object type must contain at least one attribute. The data type of an attribute can be any of the following:

- A base data type such as NUMBER, VARCHAR2, etc.
- Another object type
- A globally defined collection type (created by the CREATE TYPE command) such as a nested table or varray

An attribute gets its initial value (which may be null) when an object instance is initially created. Each object instance has its own set of attribute values.

6.1.2 Methods

Methods are SPL procedures or functions defined within an object type. Methods can be categorized into three general types:

- *Member Methods* – procedures or functions that operate within the context of an object instance. Member methods have access to, and can change the attributes of the object instance on which they are operating.
- *Static Methods* – procedures or functions that operate independently of any particular object instance. Static methods do not have access to, and cannot change the attributes of an object instance.
- *Constructor Methods* – functions used to create an instance of an object type. A default constructor method is always provided when an object type is defined.

6.1.3 Overloading Methods

In an object type it is permissible to define two or more identically named methods of the same type (this is, either a procedure or function), but with different signatures. Such methods are referred to as *overloaded* methods.

A method's signature consists of the number of formal parameters, the data types of its formal parameters, and their order.

6.2 Object Type Components

Object types are created and stored in the database by using the following two constructs of the SPL language:

- The *object type specification* - This is the public interface specifying the attributes and method signatures of the object type.
- The *object type body* - This contains the implementation of the methods specified in the object type specification.

The following sections describe the commands used to create the object type specification and the object type body.

6.2.1 Object Type Specification Syntax

The following is the syntax of the object type specification:

```
CREATE [ OR REPLACE ] TYPE name
  [ AUTHID { DEFINER | CURRENT_USER } ]
  { IS | AS } OBJECT
( { attribute { datatype | objtype | collecttype } }
  [, ...]
  [ method_spec ] [, ...]
  [ constructor ] [, ...]
) [ [ NOT ] { FINAL | INSTANTIABLE } ] ...;
```

where *method_spec* is the following:

```
[ [ NOT ] { FINAL | INSTANTIABLE } ] ...
[ OVERRIDING ]
  subprogram_spec
```

where *subprogram_spec* is the following:

```
{ MEMBER | STATIC }
{ PROCEDURE proc_name
  [ ( [ SELF [ IN | IN OUT ] name ]
    [, parm1 [ IN | IN OUT | OUT ] datatype1
      [ DEFAULT value1 ] ]
    [, parm2 [ IN | IN OUT | OUT ] datatype2
      [ DEFAULT value2 ] ]
    ) ... )
  ]
|
  FUNCTION func_name
  [ ( [ SELF [ IN | IN OUT ] name ]
    [, parm1 [ IN | IN OUT | OUT ] datatype1
      [ DEFAULT value1 ] ]
```

```
[, parm2 [ IN | IN OUT | OUT ] datatype2
    [ DEFAULT value2 ]
    ] ... )
]
RETURN return_type
}
```

where *constructor* is the following:

```
CONSTRUCTOR func_name
[ ( [ SELF [ IN | IN OUT ] name ]
    [, parm1 [ IN | IN OUT | OUT ] datatype1
        [ DEFAULT value1 ] ]
    [, parm2 [ IN | IN OUT | OUT ] datatype2
        [ DEFAULT value2 ] ]
    ] ... )
]
RETURN self AS RESULT
```

Note: The `OR REPLACE` option cannot be currently used to add, delete, or modify the attributes of an existing object type. Use the `DROP TYPE` command to first delete the existing object type. The `OR REPLACE` option can be used to add, delete, or modify the methods in an existing object type.

Note: The PostgreSQL form of the `ALTER TYPE ALTER ATTRIBUTE` command can be used to change the data type of an attribute in an existing object type. However, the `ALTER TYPE` command cannot add or delete attributes in the object type.

name is an identifier (optionally schema-qualified) assigned to the object type.

If the `AUTHID` clause is omitted or `DEFINER` is specified, the rights of the object type owner are used to determine access privileges to database objects. If `CURRENT_USER` is specified, the rights of the current user executing a method in the object are used to determine access privileges.

attribute is an identifier assigned to an attribute of the object type.

datatype is a base datatype.

objtype is a previously defined object type.

collecttype is a previously defined collection type.

Following the closing parenthesis of the `CREATE TYPE` definition, [NOT] FINAL specifies whether or not a subtype can be derived from this object type. FINAL, which is

the default, means that no subtypes can be derived from this object type. Specify NOT FINAL if you want to allow subtypes to be defined under this object type.

Note: Even though the specification of NOT FINAL is accepted in the CREATE TYPE command, SPL does not currently support the creation of subtypes.

Following the closing parenthesis of the CREATE TYPE definition, [NOT] INSTANTIABLE specifies whether or not an object instance can be created of this object type. INSTANTIABLE, which is the default, means that an instance of this object type can be created. Specify NOT INSTANTIABLE if this object type is to be used only as a parent “template” from which other specialized subtypes are to be defined. If NOT INSTANTIABLE is specified, then NOT FINAL must be specified as well. If any method in the object type contains the NOT INSTANTIABLE qualifier, then the object type, itself, must be defined with NOT INSTANTIABLE and NOT FINAL.

Note: Even though the specification of NOT INSTANTIABLE is accepted in the CREATE TYPE command, SPL does not currently support the creation of subtypes.

method_spec denotes the specification of a member method or static method.

Prior to the definition of a method, [NOT] FINAL specifies whether or not the method can be overridden in a subtype. NOT FINAL is the default meaning the method can be overridden in a subtype.

Prior to the definition of a method specify OVERRIDING if the method overrides an identically named method in a supertype. The overriding method must have the same number of identically named method parameters with the same data types and parameter modes, in the same order, and the same return type(if the method is a function) as defined in the supertype.

Prior to the definition of a method, [NOT] INSTANTIABLE specifies whether or not the object type definition provides an implementation for the method. If INSTANTIABLE is specified, then the CREATE TYPE BODY command for the object type must specify the implementation of the method. If NOT INSTANTIABLE is specified, then the CREATE TYPE BODY command for the object type must not contain the implementation of the method. In this latter case, it is assumed a subtype contains the implementation of the method, overriding the method in this object type. If there are any NOT INSTANTIABLE methods in the object type, then the object type definition itself, must specify NOT INSTANTIABLE and NOT FINAL following the closing parenthesis of the object type specification. The default is INSTANTIABLE.

subprogram_spec denotes the specification of a procedure or function and begins with the specification of either MEMBER or STATIC. A member subprogram must be invoked with respect to a particular object instance while a static subprogram is not invoked with respect to any object instance.

proc_name is an identifier of a procedure. If the `SELF` parameter is specified, *name* is the object type name given in the `CREATE TYPE` command. If specified, *parm1*, *parm2*, ... are the formal parameters of the procedure. *datatype1*, *datatype2*, ... are the data types of *parm1*, *parm2*, ... respectively. `IN`, `IN OUT`, and `OUT` are the possible parameter modes for each formal parameter. If none are specified, the default is `IN`. *value1*, *value2*, ... are default values that may be specified for `IN` parameters.

Include the `CONSTRUCTOR` keyword and function definition to define a constructor function.

func_name is an identifier of a function. If the `SELF` parameter is specified, *name* is the object type name given in the `CREATE TYPE` command. If specified, *parm1*, *parm2*, ... are the formal parameters of the function. *datatype1*, *datatype2*, ... are the data types of *parm1*, *parm2*, ... respectively. `IN`, `IN OUT`, and `OUT` are the possible parameter modes for each formal parameter. If none are specified, the default is `IN`. *value1*, *value2*, ... are default values that may be specified for `IN` parameters. *return_type* is the data type of the value the function returns.

The following points should be noted about an object type specification:

- There must be at least one attribute defined in the object type.
- There may be none, one, or more methods defined in the object type.
- For each member method there is an implicit, built-in parameter named `SELF`, whose data type is that of the object type being defined.

`SELF` refers to the object instance that is currently invoking the method. `SELF` can be explicitly declared as an `IN` or `IN OUT` parameter in the parameter list (for example as `MEMBER FUNCTION (SELF IN OUT object_type ...)`).

If `SELF` is explicitly declared, `SELF` must be the first parameter in the parameter list. If `SELF` is not explicitly declared, its parameter mode defaults to `IN OUT` for member procedures and `IN` for member functions.

- A static method cannot be overridden (`OVERRIDING` and `STATIC` cannot be specified together in *method_spec*).
- A static method must be instantiable (`NOT INSTANTIABLE` and `STATIC` cannot be specified together in *method_spec*).

6.2.2 Object Type Body Syntax

The following is the syntax of the object type body:

```
CREATE [ OR REPLACE ] TYPE BODY name
  { IS | AS }
  method_spec [...]
  [constructor] [...]
END;
```

where *method_spec* is the following:

subprogram_spec

and *subprogram_spec* is the following:

```
{ MEMBER | STATIC }
{ PROCEDURE proc_name
  [ ( [ SELF [ IN | IN OUT ] name ]
      [, parm1 [ IN | IN OUT | OUT ] datatype1
          [ DEFAULT value1 ] ]
      [, parm2 [ IN | IN OUT | OUT ] datatype2
          [ DEFAULT value2 ] ]
      ...) ]
  ]
{ IS | AS }
[ declarations ]
BEGIN
  statement; ...
[ EXCEPTION
  WHEN ... THEN
    statement; ...]
END;
|
FUNCTION func_name
  [ ( [ SELF [ IN | IN OUT ] name ]
      [, parm1 [ IN | IN OUT | OUT ] datatype1
          [ DEFAULT value1 ] ]
      [, parm2 [ IN | IN OUT | OUT ] datatype2
          [ DEFAULT value2 ] ]
      ...) ]
  ]
RETURN return_type
{ IS | AS }
[ declarations ]
BEGIN
  statement; ...
[ EXCEPTION
  WHEN ... THEN
    statement; ...]
```

```
END;
```

where *constructor* is:

```
CONSTRUCTOR func_name
[ ( [ SELF [ IN | IN OUT ] name ]
  [, parm1 [ IN | IN OUT | OUT ] datatype1
    [ DEFAULT value1 ] ]
  [, parm2 [ IN | IN OUT | OUT ] datatype2
    [ DEFAULT value2 ]
  ] ... )
  ]
RETURN self AS RESULT
{ IS | AS }
[ declarations ]
BEGIN
  statement; ...
[ EXCEPTION
  WHEN ... THEN
    statement; ...]
END;
```

name is an identifier (optionally schema-qualified) assigned to the object type.

method_spec denotes the implementation of an instantiable method that was specified in the CREATE TYPE command.

If INSTANTIABLE was specified or omitted in *method_spec* of the CREATE TYPE command, then there must be a *method_spec* for this method in the CREATE TYPE BODY command.

If NOT INSTANTIABLE was specified in *method_spec* of the CREATE TYPE command, then there must be no *method_spec* for this method in the CREATE TYPE BODY command.

subprogram_spec denotes the specification of a procedure or function and begins with the specification of either MEMBER or STATIC. The same qualifier must be used as was specified in *subprogram_spec* of the CREATE TYPE command.

proc_name is an identifier of a procedure specified in the CREATE TYPE command. The parameter declarations have the same meaning as described for the CREATE TYPE command, and must be specified in the CREATE TYPE BODY command in the same manner as specified in the CREATE TYPE command.

Include the CONSTRUCTOR keyword and function definition to define a constructor function.

func_name is an identifier of a function specified in the `CREATE TYPE` command. The parameter declarations have the same meaning as described for the `CREATE TYPE` command, and must be specified in the `CREATE TYPE BODY` command in the same manner as specified in the `CREATE TYPE` command. *return_type* is the data type of the value the function returns and must match *return_type* given in the `CREATE TYPE` command.

declarations are variable, cursor, type, or subprogram declarations. If subprogram declarations are included, they must be declared after all other variable, cursor, and type declarations.

statement is an SPL program statement.

6.3 Creating Object Types

You can use the `CREATE TYPE` command to create an object type specification, and the `CREATE TYPE BODY` command to create an object type body. This section provides some examples using the `CREATE TYPE` and `CREATE TYPE BODY` commands.

The first example creates the `addr_object_type` object type that contains only attributes and no methods:

```
CREATE OR REPLACE TYPE addr_object_type AS OBJECT
(
    street          VARCHAR2(30),
    city            VARCHAR2(20),
    state           CHAR(2),
    zip             NUMBER(5)
);
```

Since there are no methods in this object type, an object type body is not required. This example creates a composite type, which allows you to treat related objects as a single attribute.

6.3.1 Member Methods

A member method is a function or procedure that is defined within an object type and can only be invoked through an instance of that type. Member methods have access to, and can change the attributes of, the object instance on which they are operating.

The following object type specification creates the `emp_obj_typ` object type:

```
CREATE OR REPLACE TYPE emp_obj_typ AS OBJECT
(
    empno          NUMBER(4),
    ename          VARCHAR2(20),
    addr           ADDR_OBJ_TYP,
    MEMBER PROCEDURE display_emp(SELF IN OUT emp_obj_typ)
);
```

Object type `emp_obj_typ` contains a member method named `display_emp`. `display_emp` uses a `SELF` parameter, which passes the object instance on which the method is invoked.

A `SELF` parameter is a parameter whose data type is that of the object type being defined. `SELF` always refers to the instance that is invoking the method. A `SELF` parameter is the first parameter in a member procedure or function *regardless* of whether it is explicitly declared in the parameter list.

The following code snippet defines an object type body for `emp_obj_typ`:

```
CREATE OR REPLACE TYPE BODY emp_obj_typ AS
  MEMBER PROCEDURE display_emp (SELF IN OUT emp_obj_typ)
  IS
  BEGIN
    DBMS_OUTPUT.PUT_LINE('Employee No : ' || empno);
    DBMS_OUTPUT.PUT_LINE('Name : ' || ename);
    DBMS_OUTPUT.PUT_LINE('Street : ' || addr.street);
    DBMS_OUTPUT.PUT_LINE('City/State/Zip: ' || addr.city || ', ' ||
      addr.state || ' ' || LPAD(addr.zip,5,'0'));
  END;
END;
```

You can also use the `SELF` parameter in an object type body. To illustrate how the `SELF` parameter would be used in the `CREATE TYPE BODY` command, the preceding object type body could be written as follows:

```
CREATE OR REPLACE TYPE BODY emp_obj_typ AS
  MEMBER PROCEDURE display_emp (SELF IN OUT emp_obj_typ)
  IS
  BEGIN
    DBMS_OUTPUT.PUT_LINE('Employee No : ' || SELF.empno);
    DBMS_OUTPUT.PUT_LINE('Name : ' || SELF.ename);
    DBMS_OUTPUT.PUT_LINE('Street : ' || SELF.addr.street);
    DBMS_OUTPUT.PUT_LINE('City/State/Zip: ' || SELF.addr.city || ', ' ||
      SELF.addr.state || ' ' || LPAD(SELF.addr.zip,5,'0'));
  END;
END;
```

Both versions of the `emp_obj_typ` body are completely equivalent.

6.3.2 Static Methods

Like a member method, a static method belongs to a type. A static method, however, is invoked not by an *instance* of the type, but by using the *name* of the type. For example, to invoke a static function named `get_count`, defined within the `emp_obj_type` type, you would write:

```
emp_obj_type.get_count();
```

A static method does not have access to, and cannot change the attributes of an object instance, and does not typically work with an instance of the type.

The following object type specification includes a static function `get_dname` and a member procedure `display_dept`:

```
CREATE OR REPLACE TYPE dept_obj_typ AS OBJECT (
  deptno          NUMBER(2),
  STATIC FUNCTION get_dname(p_deptno IN NUMBER) RETURN VARCHAR2,
  MEMBER PROCEDURE display_dept
);
```

The object type body for `dept_obj_typ` defines a static function named `get_dname` and a member procedure named `display_dept`:

```
CREATE OR REPLACE TYPE BODY dept_obj_typ AS
  STATIC FUNCTION get_dname(p_deptno IN NUMBER) RETURN VARCHAR2
  IS
    v_dname      VARCHAR2(14);
  BEGIN
    CASE p_deptno
      WHEN 10 THEN v_dname := 'ACCOUNTING';
      WHEN 20 THEN v_dname := 'RESEARCH';
      WHEN 30 THEN v_dname := 'SALES';
      WHEN 40 THEN v_dname := 'OPERATIONS';
      ELSE v_dname := 'UNKNOWN';
    END CASE;
    RETURN v_dname;
  END;

  MEMBER PROCEDURE display_dept
  IS
  BEGIN
    DBMS_OUTPUT.PUT_LINE('Dept No    : ' || SELF.deptno);
    DBMS_OUTPUT.PUT_LINE('Dept Name   : ' ||
                         dept_obj_typ.get_dname(SELF.deptno));
  END;
END;
```

Within the static function `get_dname`, there can be no references to `SELF`. Since a static function is invoked independently of any object instance, it has no implicit access to any object attribute.

Member procedure `display_dept` can access the `deptno` attribute of the object instance passed in the `SELF` parameter. It is not necessary to explicitly declare the `SELF` parameter in the `display_dept` parameter list.

The last `DBMS_OUTPUT.PUT_LINE` statement in the `display_dept` procedure includes a call to the static function `get_dname` (qualified by its objecttype name `dept_obj_typ`).

6.3.3 Constructor Methods

A constructor method is a function that creates an instance of an object type, typically by assigning values to the members of the object. An objecttype may define several constructors to accomplish different tasks. A constructor method is a member function (invoked with a `SELF` parameter) whose name matches the name of the type.

For example, if you define a type named `address`, each constructor is named `address`. You may overload a constructor by creating one or more different constructor functions with the same name, but with different argument types.

The SPL compiler will provide a default constructor for each object type. The default constructor is a member function whose name matches the name of the type and whose argument list matches the type members (in order). For example, given an object type such as:

```
CREATE TYPE address AS OBJECT
(
    street_address VARCHAR2(40),
    postal_code    VARCHAR2(10),
    city           VARCHAR2(40),
    state          VARCHAR2(2)
)
```

The SPL compiler will provide a default constructor with the following signature:

```
CONSTRUCTOR FUNCTION address
(
    street_address VARCHAR2(40),
    postal_code    VARCHAR2(10),
    city           VARCHAR2(40),
    state          VARCHAR2(2)
)
```

The body of the default constructor simply sets each member to `NULL`.

To create a custom constructor, declare the constructor function (using the keyword `constructor`) in the `CREATE TYPE` command and define the construction function in the `CREATE TYPE BODY` command. For example, you may wish to create a custom constructor for the `address` type which computes the city and state given a `street_address` and `postal_code`:

```
CREATE TYPE address AS OBJECT
(
    street_address VARCHAR2(40),
    postal_code    VARCHAR2(10),
    city           VARCHAR2(40),
    state          VARCHAR2(2),

    CONSTRUCTOR FUNCTION address
    (
        street_address VARCHAR2,
        postal_code   VARCHAR2
    ) RETURN self AS RESULT
)

CREATE TYPE BODY address AS
    CONSTRUCTOR FUNCTION address
    (
        street_address VARCHAR2,
        postal_code   VARCHAR2
    ) RETURN self AS RESULT
IS
    BEGIN
        self.street_address := street_address;
        self.postal_code := postal_code;
        self.city := postal_code_to_city(postal_code);
```

```
    self.state := postal_code_to_state(postal_code);
    RETURN;
END;
END;
```

To create an instance of an object type, you invoke one of the constructor methods for that type. For example:

```
DECLARE
  cust_addr address := address('100 Main Street', 02203');
BEGIN
  DBMS_OUTPUT.PUT_LINE(cust_addr.city); -- displays Boston
  DBMS_OUTPUT.PUT_LINE(cust_addr.state); -- displays MA
END;
```

Custom constructor functions are typically used to compute member values when given incomplete information. The preceding example computes the values for `city` and `state` when given a postal code.

Custom constructor functions are also used to enforce business rules that restrict the state of an object. For example, if you define an object type to represent a `payment`, you can use a custom constructor to ensure that no object of type `payment` can be created with an amount that is `NULL`, negative, or zero. The default constructor would set `payment.amount` to `NULL` so you must create a custom constructor (whose signature matches the default constructor) to prohibit `NULL` amounts.

6.4 Creating Object Instances

To create an instance of an object type, you must first declare a variable of the object type, and then initialize the declared object variable. The syntax for declaring an object variable is:

object obj_type

object is an identifier assigned to the object variable.

obj_type is the identifier of a previously defined object type.

After declaring the object variable, you must invoke a *constructor method* to initialize the object with values. Use the following syntax to invoke the constructor method:

[NEW] *obj_type* ({expr1 | NULL} [, {expr2 | NULL}] [, ...])

obj_type is the identifier of the object type's constructor method; the constructor method has the same name as the previously declared object type.

expr1, expr2, ... are expressions that are type-compatible with the first attribute of the object type, the second attribute of the object type, etc. If an attribute is of an object type, then the corresponding expression can be NULL, an object initialization expression, or any expression that returns that object type.

The following anonymous block declares and initializes a variable:

```
DECLARE
    v_emp          EMP_OBJ_TYP;
BEGIN
    v_emp := emp_obj_typ(9001, 'JONES',
                         addr_obj_typ('123 MAIN STREET', 'EDISON', 'NJ', 08817));
END;
```

The variable (*v_emp*) is declared with a previously defined object type named *EMP_OBJ_TYPE*. The body of the block initializes the variable using the *emp_obj_typ* and *addr_obj_typ* constructors.

You can include the *NEW* keyword when creating a new instance of an object in the body of a block. The *NEW* keyword invokes the object constructor whose signature matches the arguments provided.

The following example declares two variables, named *mgr* and *emp*. The variables are both of *EMP_OBJ_TYPE*. The *mgr* object is initialized in the declaration, while the *emp* object is initialized to *NULL* in the declaration, and assigned a value in the body.

```
DECLARE
    mgr  EMP_OBJ_TYPE := (9002, 'SMITH');
```

```

emp    EMP_OBJ_TYPE;
BEGIN
  emp := NEW EMP_OBJ_TYPE (9003, 'RAY');
END;

```

Note: In Advanced Server, the following alternate syntax can be used in place of the constructor method.

```
[ ROW ] ({ expr1 | NULL } [, { expr2 | NULL } ] [, ...])
```

`ROW` is an optional keyword if two or more terms are specified within the parenthesis-enclosed, comma-delimited list. If only one term is specified, then specification of the `ROW` keyword is mandatory.

6.5 Referencing an Object

Once an object variable is created and initialized, individual attributes can be referenced using dot notation of the form:

```
object.attribute
```

`object` is the identifier assigned to the object variable. `attribute` is the identifier of an object type attribute.

If `attribute`, itself, is of an object type, then the reference must take the form:

```
object.attribute.attribute_inner
```

`attribute_inner` is an identifier belonging to the object type to which `attribute` references in its definition of `object`.

The following example expands upon the previous anonymous block to display the values assigned to the `emp_obj_typ` object.

```

DECLARE
  v_emp          EMP_OBJ_TYP;
BEGIN
  v_emp := emp_obj_typ(9001,'JONES',
                       addr_obj_typ('123 MAIN STREET','EDISON','NJ',08817));
  DBMS_OUTPUT.PUT_LINE('Employee No   : ' || v_emp.empno);
  DBMS_OUTPUT.PUT_LINE('Name        : ' || v_emp.ename);
  DBMS_OUTPUT.PUT_LINE('Street      : ' || v_emp.addr.street);
  DBMS_OUTPUT.PUT_LINE('City/State/Zip: ' || v_emp.addr.city || ', ' ||
                       v_emp.addr.state || ' ' || LPAD(v_emp.addr.zip,5,'0'));
END;

```

The following is the output from this anonymous block.

```
Employee No    : 9001
Name          : JONES
Street        : 123 MAIN STREET
City/State/Zip: EDISON, NJ 08817
```

Methods are called in a similar manner as attributes.

Once an object variable is created and initialized, member procedures or functions are called using dot notation of the form:

object.prog_name

object is the identifier assigned to the object variable. *prog_name* is the identifier of the procedure or function.

Static procedures or functions are not called utilizing an object variable. Instead the procedure or function is called utilizing the object type name:

object_type.prog_name

object_type is the identifier assigned to the object type. *prog_name* is the identifier of the procedure or function.

The results of the previous anonymous block can be duplicated by calling the member procedure `display_emp`:

```
DECLARE
    v_emp           EMP_OBJ_TYP;
BEGIN
    v_emp := emp_obj_typ(9001,'JONES',
                         addr_obj_typ('123 MAIN STREET','EDISON','NJ',08817));
    v_emp.display_emp;
END;
```

The following is the output from this anonymous block.

```
Employee No    : 9001
Name          : JONES
Street        : 123 MAIN STREET
City/State/Zip: EDISON, NJ 08817
```

The following anonymous block creates an instance of `dept_obj_typ` and calls the member procedure `display_dept`:

```
DECLARE
    v_dept          DEPT_OBJ_TYP := dept_obj_typ (20);
BEGIN
    v_dept.display_dept;
END;
```

The following is the output from this anonymous block.

```
Dept No    : 20
Dept Name  : RESEARCH
```

The static function defined in `dept_obj_typ` can be called directly by qualifying it by the object type name as follows:

```
BEGIN
  DBMS_OUTPUT.PUT_LINE(dept_obj_typ.get_dname(20));
END;

RESEARCH
```

6.6 Dropping an Object Type

The syntax for deleting an object type is as follows.

```
DROP TYPE objtype;
```

objtype is the identifier of the object type to be dropped. If the definition of *objtype* contains attributes that are themselves object types or collection types, these nested object types or collection types must be dropped last.

If an object type body is defined for the object type, the `DROP TYPE` command deletes the object type body as well as the object type specification. In order to recreate the complete object type, both the `CREATE TYPE` and `CREATE TYPE BODY` commands must be reissued.

The following example drops the `emp_obj_typ` and the `addr_obj_typ` object types created earlier in this chapter. `emp_obj_typ` must be dropped first since it contains `addr_obj_typ` within its definition as an attribute.

```
DROP TYPE emp_obj_typ;
DROP TYPE addr_obj_typ;
```

The syntax for deleting an object type body, but not the object type specification is as follows.

```
DROP TYPE BODY objtype;
```

The object type body can be recreated by issuing the `CREATE TYPE BODY` command.

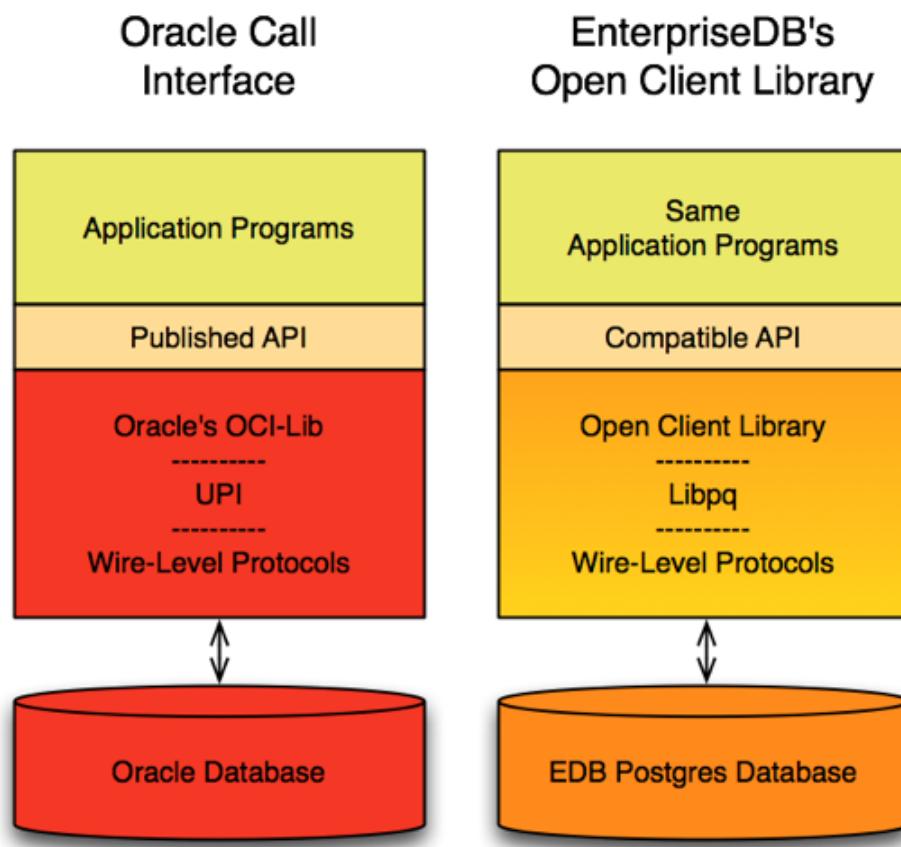
The following example drops only the object type body of the `dept_obj_typ`.

```
DROP TYPE BODY dept_obj_typ;
```

7 Open Client Library

The Open Client Library provides application interoperability with the Oracle Call Interface – an application that was formerly “locked in” can now work with either an EDB Postgres Advanced Server or an Oracle database with minimal to no changes to the application code. The EnterpriseDB implementation of the Open Client Library is written in C.

The following diagram compares the Open Client Library and Oracle Call Interface application stacks.



For detailed usage information about the Open Client Library and the supported functions, please see the EDB Postgres Advanced Server OCI Connector Guide, available at:

<https://www.enterprisedb.com/resources/product-documentation>

Please note: EnterpriseDB does not support use of the Open Client Library with Oracle Real Application Clusters (RAC) and Oracle Exadata; the aforementioned Oracle products have not been evaluated nor certified with this EnterpriseDB product.

8 Oracle Catalog Views

The Oracle Catalog Views provide information about database objects in a manner compatible with the Oracle data dictionary views. Information about the supported views is now available in the *Database Compatibility for Oracle® Developer's Reference Guide*, available at:

<https://www.enterprisedb.com/resources/product-documentation>

9 Tools and Utilities

Compatible tools and utility programs can allow a developer to work with Advanced Server in a familiar environment. The tools supported by Advanced Server include:

- EDB*Plus
- EDB*Loader
- EDB*Wrap
- The Dynamic Runtime Instrumentation Tools Architecture (DRITA)

For detailed information about the functionality supported by Advanced Server, please consult the *Database Compatibility for Oracle® Developer's Tools and Utilities Guide*, available at:

<https://www.enterprisedb.com/resources/product-documentation>

10 Table Partitioning

In a partitioned table, one logically large table is broken into smaller physical pieces. Partitioning can provide several benefits:

- Query performance can be improved dramatically in certain situations, particularly when most of the heavily accessed rows of the table are in a single partition or a small number of partitions. Partitioning allows you to omit the partition column from the front of an index, reducing index size and making it more likely that the heavily used parts of the index fits in memory.
- When a query or update accesses a large percentage of a single partition, performance may improve because the server will perform a sequential scan of the partition instead of using an index and random access reads scattered across the whole table.
- A bulk load (or unload) can be implemented by adding or removing partitions, if you plan that requirement into the partitioning design. `ALTER TABLE` is far faster than a bulk operation. It also entirely avoids the `VACUUM` overhead caused by a bulk `DELETE`.
- Seldom-used data can be migrated to less-expensive (or slower) storage media.

Table partitioning is worthwhile only when a table would otherwise be very large. The exact point at which a table will benefit from partitioning depends on the application; a good rule of thumb is that the size of the table should exceed the physical memory of the database server.

This document discusses the aspects of table partitioning compatible with Oracle databases that are supported by Advanced Server.

Note: This document and particularly the partitioning presented in this chapter do not describe the *declarative partitioning* feature, which has been introduced with PostgreSQL version 10. Note that PostgreSQL declarative partitioning is supported in Advanced Server 10 in addition to the table partitioning compatible with Oracle databases as described in this chapter. For information about declarative partitioning, please see the PostgreSQL core documentation available at:

<https://www.postgresql.org/docs/10/static/ddl-partitioning.html>

The PostgreSQL 9.6 `INSERT... ON CONFLICT DO NOTHING/UPDATE` clause (commonly known as UPSERT) is not supported on Oracle-styled partitioned tables. If you include the `ON CONFLICT DO NOTHING/UPDATE` clause when invoking the `INSERT` command to add data to a partitioned table, the server will return an error.

10.1 Selecting a Partition Type

When you create a partitioned table, you specify LIST, RANGE, or HASH partitioning rules. The partitioning rules provide a set of constraints that define the data that is stored in each partition. As new rows are added to the partitioned table, the server uses the partitioning rules to decide which partition should contain each row.

Advanced Server can also use the partitioning rules to enforce partition pruning, improving performance when responding to user queries. When selecting a partitioning type and partitioning keys for a table, you should take into consideration how the data that is stored within a table will be queried, and include often-queried columns in the partitioning rules.

List Partitioning

When you create a list-partitioned table, you specify a single partitioning key column. When adding a row to the table, the server compares the key values specified in the partitioning rule to the corresponding column within the row. If the column value matches a value in the partitioning rule, the row is stored in the partition named in the rule.

Range Partitioning

When you create a range-partitioned table, you specify one or more partitioning key columns. When you add a new row to the table, the server compares the value of the partitioning key (or keys) to the corresponding column (or columns) in a table entry. If the column values satisfy the conditions specified in the partitioning rule, the row is stored in the partition named in the rule.

Hash Partitioning

When you create a hash-partitioned table, you specify one or more partitioning key columns. Data is divided into (approx.) equal-sized partitions amongst the specified partitions. When you add a row to a hash-partitioned table, the server computes a hash value for the data in the specified column (or columns), and stores the row in a partition according to the hash value.

Subpartitioning

Subpartitioning breaks a partitioned table into smaller subsets. All subsets must be stored in the same database server cluster. A table is typically subpartitioned by a different set of columns, and may be a different subpartitioning type than the parent partition. If one partition is subpartitioned, then each partition will have at least one subpartition.

If a table is subpartitioned, no data will be stored in any of the partition tables; the data will be stored instead in the corresponding subpartitions.

10.2 Using Partition Pruning

Advanced Server's query planner uses *partition pruning* to compute an efficient plan to locate a row (or rows) that matches the conditions specified in the WHERE clause of a SELECT statement. To successfully prune partitions from an execution plan, the WHERE clause must constrain the information that is compared to the partitioning key column specified when creating the partitioned table. When querying a:

- list-partitioned table, partition pruning is effective when the WHERE clause compares a literal value to the partitioning key using operators like equal (=) or AND.
- range-partitioned table, partition pruning is effective when the WHERE clause compares a literal value to a partitioning key using operators such as equal (=), less than (<), or greater than (>).
- hash-partitioned table, partition pruning is effective when the WHERE clause compares a literal value to the partitioning key using an operator such as equal (=).

The partition pruning mechanism uses two optimization techniques:

- Fast Pruning
- Constraint exclusion

Partition pruning techniques limit the search for data to only those partitions in which the values for which you are searching might reside. Both pruning techniques remove partitions from a query's execution plan, increasing performance.

The difference between the fast pruning and constraint exclusion is that fast pruning understands the relationship between the partitions in an Oracle-partitioned table, while constraint exclusion does not. For example, when a query searches for a specific value within a list-partitioned table, fast pruning can reason that only a specific partition may hold that value, while constraint exclusion must examine the constraints defined for *each* partition. Fast pruning occurs early in the planning process to reduce the number of partitions that the planner must consider, while constraint exclusion occurs late in the planning process.

Using Constraint Exclusion

The `constraint_exclusion` parameter controls constraint exclusion. The `constraint_exclusion` parameter may have a value of `on`, `off`, or `partition`. To enable constraint exclusion, the parameter must be set to *either* `partition` or `on`. By default, the parameter is set to `partition`.

For more information about constraint exclusion, see:

<https://www.postgresql.org/docs/10/static/ddl-partitioning.html>

When constraint exclusion is enabled, the server examines the constraints defined for each partition to determine if that partition can satisfy a query.

When you execute a `SELECT` statement that *does not* contain a `WHERE` clause, the query planner must recommend an execution plan that searches the entire table. When you execute a `SELECT` statement that *does* contain a `WHERE` clause, the query planner determines in which partition that row would be stored, and sends query fragments to that partition, pruning the partitions that could not contain that row from the execution plan. If you are not using partitioned tables, disabling constraint exclusion may improve performance.

Fast Pruning

Like constraint exclusion, fast pruning can only optimize queries that include a `WHERE` (or join) clause, and only when the qualifiers in the `WHERE` clause match a certain form. In both cases, the query planner will avoid searching for data within partitions that cannot possibly hold the data required by the query.

Fast pruning is controlled by a boolean configuration parameter named `edb_enable_pruning`. If `edb_enable_pruning` is `ON`, Advanced Server will fast prune certain queries. If `edb_enable_pruning` is `OFF`, the server will disable fast pruning.

Please note: Fast pruning cannot optimize queries against subpartitioned tables or optimize queries against range-partitioned tables that are partitioned on more than one column.

For LIST-partitioned tables, Advanced Server can fast prune queries that contain a `WHERE` clause that constrains a partitioning column to a literal value. For example, given a LIST-partitioned table such as:

```
CREATE TABLE sales_hist(..., country text, ...)
PARTITION BY LIST(country)

(
    PARTITION americas VALUES('US', 'CA', 'MX'),
    PARTITION europe VALUES('BE', 'NL', 'FR'),
    PARTITION asia VALUES('JP', 'PK', 'CN'),
    PARTITION others VALUES(DEFAULT)
)
```

Fast pruning can reason about `WHERE` clauses such as:

```

WHERE country = 'US'

WHERE country IS NULL;

```

Given the first WHERE clause, fast pruning would eliminate partitions europe, asia, and others because those partitions cannot hold rows that satisfy the qualifier: WHERE country = 'US'.

Given the second WHERE clause, fast pruning would eliminate partitions americas, europe, and asia because those partitions cannot hold rows where country IS NULL.

The operator specified in the WHERE clause must be an equal sign (=) or the equality operator appropriate for the data type of the partitioning column.

For range-partitioned tables, Advanced Server can fast prune queries that contain a WHERE clause that constrains a partitioning column to a literal value, but the operator may be any of the following:

```

>
>=
=
<=
<

```

Fast pruning will also reason about more complex expressions involving AND and BETWEEN operators, such as:

```

WHERE size > 100 AND size <= 200
WHERE size BETWEEN 100 AND 200

```

But cannot prune based on expressions involving OR or IN.

For example, when querying a RANGE-partitioned table, such as:

```

CREATE TABLE boxes(id int, size int, color text)
PARTITION BY RANGE(size)
(
    PARTITION small VALUES LESS THAN(100),
    PARTITION medium VALUES LESS THAN(200),
    PARTITION large VALUES LESS THAN(300)
)

```

Fast pruning can reason about WHERE clauses such as:

```

WHERE size > 100      -- scan partitions 'medium' and 'large'

WHERE size >= 100     -- scan partitions 'medium' and 'large'

```

```
WHERE size = 100      -- scan partition 'medium'  
WHERE size <= 100     -- scan partitions 'small' and 'medium'  
WHERE size < 100      -- scan partition 'small'  
WHERE size > 100 AND size < 199      -- scan partition 'medium'  
WHERE size BETWEEN 100 AND 199      -- scan partition 'medium'  
WHERE color = 'red' AND size = 100   -- scan 'medium'  
WHERE color = 'red' AND (size > 100 AND size < 199) -- scan 'medium'
```

In each case, fastpruning requires that the qualifier must refer to a partitioning column and literal value (or IS NULL/IS NOT NULL).

Note that fastpruning can also optimize DELETE and UPDATE statements containing WHERE clauses of the forms described above.

10.2.1 Example - Partition Pruning

The EXPLAIN statement displays the execution plan of a statement. You can use the EXPLAIN statement to confirm that Advanced Server is pruning partitions from the execution plan of a query.

To demonstrate the efficiency of partition pruning, first create a simple table:

```
CREATE TABLE sales
(
    dept_no      number,
    part_no      varchar2,
    country      varchar2(20),
    date         date,
    amount        number
)
PARTITION BY LIST(country)
(
    PARTITION europe VALUES ('FRANCE', 'ITALY'),
    PARTITION asia VALUES ('INDIA', 'PAKISTAN'),
    PARTITION americas VALUES('US', 'CANADA')
);
```

Then, perform a constrained query that includes the EXPLAIN statement:

```
EXPLAIN (COSTS OFF) SELECT * FROM sales WHERE country = 'INDIA';
```

The resulting query plan shows that the server will scan only the sales_asia table - the table in which a row with a country value of INDIA would be stored:

```
edb=# EXPLAIN (COSTS OFF) SELECT * FROM sales WHERE country = 'INDIA';
          QUERY PLAN
-----
Append
-> Seq Scan on sales_asia
      Filter: ((country)::text = 'INDIA'::text)
(3 rows)
```

If you perform a query that searches for a row that matches a value not included in the partitioning key:

```
EXPLAIN (COSTS OFF) SELECT * FROM sales WHERE dept_no = '30';
```

The resulting query plan shows that the server must look in all of the partitions to locate the rows that satisfy the query:

```
edb=# EXPLAIN (COSTS OFF) SELECT * FROM sales WHERE dept_no = '30';
          QUERY PLAN
```

```
-----
Append
-> Seq Scan on sales_americas
      Filter: (dept_no = '30'::numeric)
-> Seq Scan on sales_europe
      Filter: (dept_no = '30'::numeric)
-> Seq Scan on sales_asia
      Filter: (dept_no = '30'::numeric)
(7 rows)
```

Constraint exclusion also applies when querying subpartitioned tables:

```
CREATE TABLE sales
(
    dept_no      number,
    part_no      varchar2,
    country      varchar2(20),
    date         date,
    amount       number
)
PARTITION BY RANGE(date) SUBPARTITION BY LIST(country)
(
    PARTITION "2011" VALUES LESS THAN ('01-JAN-2012')
    (
        SUBPARTITION europe_2011 VALUES ('ITALY', 'FRANCE'),
        SUBPARTITION asia_2011 VALUES ('PAKISTAN', 'INDIA'),
        SUBPARTITION americas_2011 VALUES ('US', 'CANADA')
    ),
    PARTITION "2012" VALUES LESS THAN ('01-JAN-2013')
    (
        SUBPARTITION europe_2012 VALUES ('ITALY', 'FRANCE'),
        SUBPARTITION asia_2012 VALUES ('PAKISTAN', 'INDIA'),
        SUBPARTITION americas_2012 VALUES ('US', 'CANADA')
    ),
    PARTITION "2013" VALUES LESS THAN ('01-JAN-2015')
    (
        SUBPARTITION europe_2013 VALUES ('ITALY', 'FRANCE'),
        SUBPARTITION asia_2013 VALUES ('PAKISTAN', 'INDIA'),
        SUBPARTITION americas_2013 VALUES ('US', 'CANADA')
    )
);
```

When you query the table, the query planner prunes any partitions or subpartitions from the search path that cannot possibly contain the desired result set:

```
edb=# EXPLAIN (COSTS OFF) SELECT * FROM sales WHERE country = 'US' AND date =
'Dec 12, 2012';
          QUERY PLAN
-----
Append
-> Seq Scan on sales_americas_2012
      Filter: (((country)::text = 'US'::text) AND (date = '12-DEC-12
00:00:00'::timestamp without time zone))
```

(3 rows)

10.3 Partitioning Commands Compatible with Oracle Databases

The following sections provide information about using the table partitioning syntax compatible with Oracle databases supported by Advanced Server.

10.3.1 CREATE TABLE...PARTITION BY

Use the PARTITION BY clause of the CREATE TABLE command to create a partitioned table with data distributed amongst one or more partitions (and subpartitions). The command syntax comes in the following forms:

List Partitioning Syntax

Use the first form to create a list-partitioned table:

```
CREATE TABLE [ schema. ] table_name
    table_definition
    PARTITION BY LIST(column)
    [SUBPARTITION BY {RANGE|LIST|HASH} (column[, column]...)]
    (list_partition_definition[, list_partition_definition]...);
```

Where *list_partition_definition* is:

```
PARTITION [partition_name]
    VALUES (value[, value]...)
    [TABLESPACE tablespace_name]
    [(subpartition, ...)]
```

Range Partitioning Syntax

Use the second form to create a range-partitioned table:

```
CREATE TABLE [ schema. ] table_name
    table_definition
    PARTITION BY RANGE(column[, column]...)
    [SUBPARTITION BY {RANGE|LIST|HASH} (column[, column]...)]
    (range_partition_definition[, range_partition_definition]...);
```

Where *range_partition_definition* is:

```
PARTITION [partition_name]
    VALUES LESS THAN (value[, value]...)
    [TABLESPACE tablespace_name]
    [(subpartition, ...)]
```

Hash Partitioning Syntax

Use the third form to create a hash-partitioned table:

```
CREATE TABLE [ schema. ]table_name
  table_definition
  PARTITION BY HASH(column[, column]...)
    [SUBPARTITION BY {RANGE|LIST|HASH} (column[, column]...)]
      (hash_partition_definition[, hash_partition_definition]...);
```

Where *hash_partition_definition* is:

```
[PARTITION partition_name]
  [TABLESPACE tablespace_name]
  [(subpartition, ...)]
```

Subpartitioning Syntax

subpartition may be one of the following:

```
{list_subpartition | range_subpartition | hash_subpartition}
```

where *list_subpartition* is:

```
SUBPARTITION [subpartition_name]
  VALUES (value[, value]...)
  [TABLESPACE tablespace_name]
```

where *range_subpartition* is:

```
SUBPARTITION [subpartition_name]
  VALUES LESS THAN (value[, value]...)
  [TABLESPACE tablespace_name]
```

where *hash_subpartition* is:

```
[SUBPARTITION subpartition_name]
  [TABLESPACE tablespace_name]
```

Description

The CREATE TABLE... PARTITION BY command creates a table with one or more partitions; each partition may have one or more subpartitions. There is no upper limit to the number of defined partitions, but if you include the PARTITION BY clause, you must specify at least one partitioning rule. The resulting table will be owned by the user that creates it.

Use the PARTITION BY LIST clause to divide a table into partitions based on the values entered in a specified column. Each partitioning rule must specify at least one literal value, but there is no upper limit placed on the number of values you may specify. Include a rule that specifies a matching value of DEFAULT to direct any un-qualified rows

to the given partition; for more information about using the `DEFAULT` keyword, see Section [10.4](#).

Use the `PARTITION BY RANGE` clause to specify boundary rules by which to create partitions. Each partitioning rule must contain at least one column of a data type that has two operators (i.e., a greater-than or equal to operator, and a less-than operator). Range boundaries are evaluated against a `LESS THAN` clause and are non-inclusive; a date boundary of January 1, 2013 will include only those date values that fall on or before December 31, 2012.

Range partition rules must be specified in ascending order. `INSERT` commands that store rows with values that exceed the top boundary of a range-partitioned table will fail unless the partitioning rules include a boundary rule that specifies a value of `MAXVALUE`. If you do not include a `MAXVALUE` partitioning rule, any row that exceeds the maximum limit specified by the boundary rules will result in an error.

For more information about using the `MAXVALUE` keyword, see Section [10.4](#).

Use the `PARTITION BY HASH` clause to create a hash-partitioned table. In a `HASH` partitioned table, data is divided amongst equal-sized partitions based on the hash value of the column specified in the partitioning syntax. When specifying a `HASH` partition, choose a column (or combination of columns) that is as close to unique as possible to help ensure that data is evenly distributed amongst the partitions. When selecting a partitioning column (or combination of columns), select a column (or columns) that you frequently search for exact matches for best performance.

Use the `TABLESPACE` keyword to specify the name of a tablespace on which a partition or subpartition will reside; if you do not specify a tablespace, the partition or subpartition will reside in the default tablespace.

If a table definition includes the `SUBPARTITION BY` clause, each partition within that table will have at least one subpartition. Each subpartition may be explicitly defined or system-defined.

If the subpartition is system-defined, the server-generated subpartition will reside in the default tablespace, and the name of the subpartition will be assigned by the server. The server will create:

- A `DEFAULT` subpartition if the `SUBPARTITION BY` clause specifies `LIST`.
- A `MAXVALUE` subpartition if the `SUBPARTITION BY` clause specifies `RANGE`.

The server will generate a subpartition name that is a combination of the partition table name and a unique identifier. You can query the `ALL_TAB_SUBPARTITIONS` table to review a complete list of subpartition names.

Note: For Advanced Server 10, an index cannot be created on a partitioned table. For example on the partitioned table named `sales`, you will get the following error message:

```
edb=# CREATE INDEX ON sales (part_no);
ERROR:  cannot create index on partitioned table "sales"
```

Parameters

table_name

The name (optionally schema-qualified) of the table to be created.

table_definition

The column names, data types, and constraint information as described in the PostgreSQL core documentation for the `CREATE TABLE` statement, available at:

<https://www.postgresql.org/docs/10/static/sql-createtable.html>

partition_name

The name of the partition to be created. Partition names must be unique amongst all partitions and subpartitions, and must follow the naming conventions for object identifiers.

subpartition_name

The name of the subpartition to be created. Subpartition names must be unique amongst all partitions and subpartitions, and must follow the naming conventions for object identifiers.

column

The name of a column on which the partitioning rules are based. Each row will be stored in a partition that corresponds to the `value` of the specified column(s).

`(value[, value]...)`

Use `value` to specify a quoted literal value (or comma-delimited list of literal values) by which table entries will be grouped into partitions. Each partitioning rule must specify at least one value, but there is no limit placed on the number of values specified within a rule. `value` may be `NULL`, `DEFAULT` (if specifying a `LIST` partition), or `MAXVALUE` (if specifying a `RANGE` partition).

When specifying rules for a list-partitioned table, include the `DEFAULT` keyword in the last partition rule to direct any un-matched rows to the given partition. If you do not include a rule that includes a value of `DEFAULT`, any `INSERT` statement that attempts to

add a row that does not match the specified rules of at least one partition will fail, and return an error.

When specifying rules for a list-partitioned table, include the `MAXVALUE` keyword in the last partition rule to direct any un-categorized rows to the given partition. If you do not include a `MAXVALUE` partition, any `INSERT` statement that attempts to add a row where the partitioning key is greater than the highest value specified will fail, and return an error.

`tablespace_name`

The name of the tablespace in which the partition or subpartition resides.

10.3.1.1 Example - PARTITION BY LIST

The following example creates a partitioned table (`sales`) using the `PARTITION BY LIST` clause. The `sales` table stores information in three partitions (`europe`, `asia`, and `americas`):

```
CREATE TABLE sales
(
    dept_no      number,
    part_no      varchar2,
    country      varchar2(20),
    date         date,
    amount        number
)
PARTITION BY LIST(country)
(
    PARTITION europe VALUES ('FRANCE', 'ITALY'),
    PARTITION asia VALUES ('INDIA', 'PAKISTAN'),
    PARTITION americas VALUES('US', 'CANADA')
);
```

The resulting table is partitioned by the value specified in the `country` column:

```
acctg=# SELECT partition_name, high_value from ALL_TAB_PARTITIONS;
partition_name | high_value
-----+-----
EUROPE        | FOR VALUES IN ('FRANCE', 'ITALY')
ASIA          | FOR VALUES IN ('INDIA', 'PAKISTAN')
AMERICAS      | FOR VALUES IN ('US', 'CANADA')
(3 rows)
```

- Rows with a value of `US` or `CANADA` in the `country` column are stored in the `americas` partition.

- Rows with a value of INDIA or PAKISTAN in the country column are stored in the asia partition.
- Rows with a value of FRANCE or ITALY in the country column are stored in the europe partition.

The server would evaluate the following statement against the partitioning rules, and store the row in the europe partition:

```
INSERT INTO sales VALUES (10, '9519a', 'FRANCE', '18-Aug-2012',
'650000');
```

10.3.1.2 Example - PARTITION BY RANGE

The following example creates a partitioned table (`sales`) using the PARTITION BY RANGE clause. The `sales` table stores information in four partitions (q1_2012, q2_2012, q3_2012 and q4_2012):

```
CREATE TABLE sales
(
    dept_no      number,
    part_no      varchar2,
    country      varchar2(20),
    date         date,
    amount       number
)
PARTITION BY RANGE(date)
(
    PARTITION q1_2012
        VALUES LESS THAN('2012-Apr-01'),
    PARTITION q2_2012
        VALUES LESS THAN('2012-Jul-01'),
    PARTITION q3_2012
        VALUES LESS THAN('2012-Oct-01'),
    PARTITION q4_2012
        VALUES LESS THAN('2013-Jan-01')
);
```

The resulting table is partitioned by the value specified in the `date` column:

partition_name	high_value
Q1_2012	FOR VALUES FROM (MINVALUE) TO ('01-APR-12 00:00:00')
Q2_2012	FOR VALUES FROM ('01-APR-12 00:00:00') TO ('01-JUL-12 00:00:00')
Q3_2012	FOR VALUES FROM ('01-JUL-12 00:00:00') TO ('01-OCT-12 00:00:00')
Q4_2012	FOR VALUES FROM ('01-OCT-12 00:00:00') TO ('01-JAN-13 00:00:00')

- Any row with a value in the `date` column before April 1, 2012 is stored in a partition named `q1_2012`.
- Any row with a value in the `date` column before July 1, 2012 is stored in a partition named `q2_2012`.
- Any row with a value in the `date` column before October 1, 2012 is stored in a partition named `q3_2012`.
- Any row with a value in the `date` column before January 1, 2013 is stored in a partition named `q4_2012`.

The server would evaluate the following statement against the partitioning rules and store the row in the `q3_2012` partition:

```
INSERT INTO sales VALUES (10, '9519a', 'FRANCE', '18-Aug-2012',
'650000');
```

10.3.1.3 Example - PARTITION BY HASH

The following example creates a partitioned table (`sales`) using the `PARTITION BY HASH` clause. The `sales` table stores information in three partitions (`p1`, `p2`, and `p3`):

```
CREATE TABLE sales
(
    dept_no      number,
    part_no      varchar2,
    country      varchar2(20),
    date         date,
    amount        number
)
PARTITION BY HASH (part_no)
(
    PARTITION p1,
    PARTITION p2,
    PARTITION p3
);
```

The table is partitioned by the hash value of the value specified in the `part_no` column:

```
acctg=# SELECT partition_name, high_value from ALL_TAB_PARTITIONS;
partition_name | high_value
-----+-----
P1            | FOR VALUES WITH (modulus 3, remainder 0)
P2            | FOR VALUES WITH (modulus 3, remainder 1)
P3            | FOR VALUES WITH (modulus 3, remainder 2)
(3 rows)
```

The server will evaluate the hash value of the `part_no` column, and distribute the rows into approximately equal partitions.

10.3.1.4 Example - PARTITION BY RANGE, SUBPARTITION BY LIST

The following example creates a partitioned table (`sales`) that is first partitioned by the transaction date; the range partitions (`q1_2012`, `q2_2012`, `q3_2012` and `q4_2012`) are then list-subpartitioned using the value of the `country` column.

```
CREATE TABLE sales
(
    dept_no      number,
    part_no      varchar2,
    country      varchar2(20),
    date         date,
    amount        number
)
PARTITION BY RANGE(date)
    SUBPARTITION BY LIST(country)
    (
        PARTITION q1_2012
            VALUES LESS THAN('2012-Apr-01')
            (
                SUBPARTITION q1_europe VALUES ('FRANCE', 'ITALY'),
                SUBPARTITION q1_asia VALUES ('INDIA', 'PAKISTAN'),
                SUBPARTITION q1_americas VALUES ('US', 'CANADA')
            ),
        PARTITION q2_2012
            VALUES LESS THAN('2012-Jul-01')
            (
                SUBPARTITION q2_europe VALUES ('FRANCE', 'ITALY'),
                SUBPARTITION q2_asia VALUES ('INDIA', 'PAKISTAN'),
                SUBPARTITION q2_americas VALUES ('US', 'CANADA')
            ),
        PARTITION q3_2012
            VALUES LESS THAN('2012-Oct-01')
            (
                SUBPARTITION q3_europe VALUES ('FRANCE', 'ITALY'),
                SUBPARTITION q3_asia VALUES ('INDIA', 'PAKISTAN'),
                SUBPARTITION q3_americas VALUES ('US', 'CANADA')
            ),
        PARTITION q4_2012
            VALUES LESS THAN('2013-Jan-01')
            (
                SUBPARTITION q4_europe VALUES ('FRANCE', 'ITALY'),
                SUBPARTITION q4_asia VALUES ('INDIA', 'PAKISTAN'),
                SUBPARTITION q4_americas VALUES ('US', 'CANADA')
            )
    );

```

This statement creates a table with four partitions; each partition has three subpartitions:

```
acctg=# SELECT subpartition_name, high_value, partition_name FROM
ALL_TAB_SUBPARTITIONS;
subpartition_name |          high_value          | partition_name
-----+-----+-----+
Q1_AMERICAS     | FOR VALUES IN ('US', 'CANADA') | Q1_2012
Q1_ASIA          | FOR VALUES IN ('INDIA', 'PAKISTAN') | Q1_2012
Q1_EUROPE         | FOR VALUES IN ('FRANCE', 'ITALY') | Q1_2012
Q2_AMERICAS     | FOR VALUES IN ('US', 'CANADA') | Q2_2012
Q2_ASIA          | FOR VALUES IN ('INDIA', 'PAKISTAN') | Q2_2012
Q2_EUROPE         | FOR VALUES IN ('FRANCE', 'ITALY') | Q2_2012
Q3_AMERICAS     | FOR VALUES IN ('US', 'CANADA') | Q3_2012
Q3_ASIA          | FOR VALUES IN ('INDIA', 'PAKISTAN') | Q3_2012
Q3_EUROPE         | FOR VALUES IN ('FRANCE', 'ITALY') | Q3_2012
Q4_AMERICAS     | FOR VALUES IN ('US', 'CANADA') | Q4_2012
Q4_ASIA          | FOR VALUES IN ('INDIA', 'PAKISTAN') | Q4_2012
Q4_EUROPE         | FOR VALUES IN ('FRANCE', 'ITALY') | Q4_2012
(12 rows)
```

When a row is added to this table, the value in the `date` column is compared to the values specified in the range partitioning rules, and the server selects the partition in which the row should reside. The value in the `country` column is then compared to the values specified in the list subpartitioning rules; when the server locates a match for the value, the row is stored in the corresponding subpartition.

Any row added to the table will be stored in a subpartition, so the partitions will contain no data.

The server would evaluate the following statement against the partitioning and subpartitioning rules and store the row in the `q3_europe` partition:

```
INSERT INTO sales VALUES (10, '9519a', 'FRANCE', '18-Aug-2012',
'650000');
```

10.3.2 ALTER TABLE...ADD PARTITION

Use the `ALTER TABLE... ADD PARTITION` command to add a partition to an existing partitioned table. The syntax is:

```
ALTER TABLE table_name ADD PARTITION partition_definition;
```

Where *partition_definition* is:

```
{list_partition | range_partition }
```

and *list_partition* is:

```
PARTITION [partition_name]
    VALUES (value[, value]...)
    [TABLESPACE tablespace_name]
    [(subpartition, ...)]
```

and *range_partition* is:

```
PARTITION [partition_name]
    VALUES LESS THAN (value[, value]...)
    [TABLESPACE tablespace_name]
    [(subpartition, ...)]
```

Where *subpartition* is:

```
{list_subpartition | range_subpartition | hash_subpartition}
```

and *list_subpartition* is:

```
SUBPARTITION [subpartition_name]
    VALUES (value[, value]...)
    [TABLESPACE tablespace_name]
```

and *range_subpartition* is:

```
SUBPARTITION [subpartition_name ]
    VALUES LESS THAN (value[, value]...)
    [TABLESPACE tablespace_name]
```

Description

The `ALTER TABLE... ADD PARTITION` command adds a partition to an existing partitioned table. There is no upper limit to the number of defined partitions in a partitioned table.

New partitions must be of the same type (LIST, RANGE or HASH) as existing partitions. The new partition rules must reference the same column specified in the partitioning rules that define the existing partition(s).

You cannot use the ALTER TABLE...ADD PARTITION statement to add a partition to a table with a MAXVALUE or DEFAULT rule. Note that you can alternatively use the ALTER TABLE...SPLIT PARTITION statement to split an existing partition, effectively increasing the number of partitions in a table.

RANGE partitions must be specified in ascending order. You cannot add a new partition that precedes existing partitions in a RANGE partitioned table.

Include the TABLESPACE clause to specify the tablespace in which the new partition will reside. If you do not specify a tablespace, the partition will reside in the default tablespace.

If the table is indexed, the index will be created on the new partition.

To use the ALTER TABLE...ADD PARTITION command you must be the table owner, or have superuser (or administrative) privileges.

Parameters

table_name

The name (optionally schema-qualified) of the partitioned table.

partition_name

The name of the partition to be created. Partition names must be unique amongst all partitions and subpartitions, and must follow the naming conventions for object identifiers.

subpartition_name

The name of the subpartition to be created. Subpartition names must be unique amongst all partitions and subpartitions, and must follow the naming conventions for object identifiers.

(*value*[, *value*]...)

Use *value* to specify a quoted literal value (or comma-delimited list of literal values) by which rows will be distributed into partitions. Each partitioning rule must specify at least one *value*, but there is no limit placed on the number of

values specified within a rule. `value` may also be `NONE`, `DEFAULT` (if specifying a `LIST` partition), or `MAXVALUE` (if specifying a `RANGE` partition).

For information about creating a `DEFAULT` or `MAXVALUE` partition, see Section [10.4](#).

`tablespace_name`

The name of the tablespace in which a partition or subpartition resides.

10.3.2.1 Example - Adding a Partition to a LIST Partitioned Table

The example that follows adds a partition to the list-partitioned `sales` table. The table was created using the command:

```
CREATE TABLE sales
(
    dept_no      number,
    part_no      varchar2,
    country      varchar2(20),
    date         date,
    amount        number
)
PARTITION BY LIST(country)
(
    PARTITION europe VALUES ('FRANCE', 'ITALY'),
    PARTITION asia VALUES ('INDIA', 'PAKISTAN'),
    PARTITION americas VALUES('US', 'CANADA')
);
```

The table contains three partitions (`americas`, `asia`, and `europe`):

```
acctg=# SELECT partition_name, high_value FROM ALL_TAB_PARTITIONS;
partition_name | high_value
-----+-----
EUROPE        | FOR VALUES IN ('FRANCE', 'ITALY')
ASIA          | FOR VALUES IN ('INDIA', 'PAKISTAN')
AMERICAS      | FOR VALUES IN ('US', 'CANADA')
(3 rows)
```

The following command adds a partition named `east_asia` to the `sales` table:

```
ALTER TABLE sales ADD PARTITION east_asia
VALUES ('CHINA', 'KOREA');
```

After invoking the command, the table includes the `east_asia` partition:

```
acctg=# SELECT partition_name, high_value FROM ALL_TAB_PARTITIONS;
partition_name | high_value
-----+-----
```

```

EUROPE      | FOR VALUES IN ('FRANCE', 'ITALY')
ASIA        | FOR VALUES IN ('INDIA', 'PAKISTAN')
AMERICAS    | FOR VALUES IN ('US', 'CANADA')
EAST_ASIA   | FOR VALUES IN ('CHINA', 'KOREA')
(4 rows)

```

10.3.2.2 Example - Adding a Partition to a RANGE Partitioned Table

The example that follows adds a partition to a range-partitioned table named `sales`:

```

CREATE TABLE sales
(
  dept_no      number,
  part_no      varchar2,
  country      varchar2(20),
  date         date,
  amount        number
)
PARTITION BY RANGE (date)
(
  PARTITION q1_2012
    VALUES LESS THAN ('2012-Apr-01'),
  PARTITION q2_2012
    VALUES LESS THAN ('2012-Jul-01'),
  PARTITION q3_2012
    VALUES LESS THAN ('2012-Oct-01'),
  PARTITION q4_2012
    VALUES LESS THAN ('2013-Jan-01')
);

```

The table contains four partitions (`q1_2012`, `q2_2012`, `q3_2012`, and `q4_2012`):

```

acctg=# SELECT partition_name, high_value FROM ALL_TAB_PARTITIONS;
partition_name | high_value
-----+-----
Q1_2012       | FOR VALUES FROM (MINVALUE) TO ('01-APR-12 00:00:00')
Q2_2012       | FOR VALUES FROM ('01-APR-12 00:00:00') TO ('01-JUL-12 00:00:00')
Q3_2012       | FOR VALUES FROM ('01-JUL-12 00:00:00') TO ('01-OCT-12 00:00:00')
Q4_2012       | FOR VALUES FROM ('01-OCT-12 00:00:00') TO ('01-JAN-13 00:00:00')
(4 rows)

```

The following command adds a partition named `q1_2013` to the `sales` table:

```

ALTER TABLE sales ADD PARTITION q1_2013
  VALUES LESS THAN ('01-APR-2013');

```

After invoking the command, the table includes the `q1_2013` partition:

```

acctg=# SELECT partition_name, high_value FROM ALL_TAB_PARTITIONS;
partition_name | high_value
-----+-----
Q1_2012       | FOR VALUES FROM (MINVALUE) TO ('01-APR-12 00:00:00')

```

Database Compatibility for Oracle® Developers Guide

```
Q2_2012      | FOR VALUES FROM ('01-APR-12 00:00:00') TO ('01-JUL-12 00:00:00')
Q3_2012      | FOR VALUES FROM ('01-JUL-12 00:00:00') TO ('01-OCT-12 00:00:00')
Q4_2012      | FOR VALUES FROM ('01-OCT-12 00:00:00') TO ('01-JAN-13 00:00:00')
Q1_2013      | FOR VALUES FROM ('01-JAN-13 00:00:00') TO ('01-APR-13 00:00:00')
(5 rows)
```

10.3.3 ALTER TABLE... ADD SUBPARTITION

The ALTER TABLE... ADD SUBPARTITION command adds a subpartition to an existing subpartitioned partition. The syntax is:

```
ALTER TABLE table_name MODIFY PARTITION partition_name
    ADD SUBPARTITION subpartition_definition;
```

Where *subpartition_definition* is:

```
{list_subpartition | range_subpartition}
```

and *list_subpartition* is:

```
SUBPARTITION [subpartition_name]
    VALUES (value[, value]...)
    [TABLESPACE tablespace_name]
```

and *range_subpartition* is:

```
SUBPARTITION [subpartition_name]
    VALUES LESS THAN (value[, value]...)
    [TABLESPACE tablespace_name]
```

Description

The ALTER TABLE... ADD SUBPARTITION command adds a subpartition to an existing partition; the partition must already be subpartitioned. There is no upper limit to the number of defined subpartitions.

New subpartitions must be of the same type (LIST, RANGE or HASH) as existing subpartitions. The new subpartition rules must reference the same column specified in the subpartitioning rules that define the existing subpartition(s).

You cannot use the ALTER TABLE... ADD SUBPARTITION statement to add a subpartition to a table with a MAXVALUE or DEFAULT rule, but you can split an existing subpartition with the ALTER TABLE... SPLIT SUBPARTITION statement, effectively adding a subpartition to a table.

You cannot add a new subpartition that precedes existing subpartitions in a range subpartitioned table; range subpartitions must be specified in ascending order.

Include the TABLESPACE clause to specify the tablespace in which the subpartition will reside. If you do not specify a tablespace, the subpartition will be created in the default tablespace.

If the table is indexed, the index will be created on the new subpartition.

To use the `ALTER TABLE... ADD SUBPARTITION` command you must be the table owner, or have superuser (or administrative) privileges.

Parameters

table_name

The name (optionally schema-qualified) of the partitioned table in which the subpartition will reside.

partition_name

The name of the partition in which the new subpartition will reside.

subpartition_name

The name of the subpartition to be created. Subpartition names must be unique amongst all partitions and subpartitions, and must follow the naming conventions for object identifiers.

(*value*[, *value*]...)

Use *value* to specify a quoted literal value (or comma-delimited list of literal values) by which table entries will be grouped into partitions. Each partitioning rule must specify at least one value, but there is no limit placed on the number of values specified within a rule. *value* may also be `NONE`, `DEFAULT` (if specifying a `LIST` partition), or `MAXVALUE` (if specifying a `RANGE` partition).

For information about creating a `DEFAULT` or `MAXVALUE` partition, see Section [10.4](#).

tablespace_name

The name of the tablespace in which the subpartition resides.

10.3.3.1 Example - Adding a Subpartition to a LIST-RANGE Partitioned Table

The following example adds a `RANGE` subpartition to the list-partitioned `sales` table. The `sales` table was created with the command:

```
CREATE TABLE sales
```

```

(
    dept_no      number,
    part_no      varchar2,
    country      varchar2(20),
    date         date,
    amount       number
)
PARTITION BY LIST(country)
    SUBPARTITION BY RANGE(date)
(
    PARTITION europe VALUES('FRANCE', 'ITALY')
    (
        SUBPARTITION europe_2011
            VALUES LESS THAN('2012-Jan-01'),
        SUBPARTITION europe_2012
            VALUES LESS THAN('2013-Jan-01')
    ),
    PARTITION asia VALUES('INDIA', 'PAKISTAN')
    (
        SUBPARTITION asia_2011
            VALUES LESS THAN('2012-Jan-01'),
        SUBPARTITION asia_2012
            VALUES LESS THAN('2013-Jan-01')
    ),
    PARTITION americas VALUES('US', 'CANADA')
    (
        SUBPARTITION americas_2011
            VALUES LESS THAN('2012-Jan-01'),
        SUBPARTITION americas_2012
            VALUES LESS THAN('2013-Jan-01')
    )
);

```

The `sales` table has three partitions, named `europe`, `asia`, and `americas`. Each partition has two range-defined subpartitions:

```

acctg=# SELECT partition_name, subpartition_name, high_value FROM
ALL_TAB_SUBPARTITIONS;
  partition_name | subpartition_name | high_value
-----+-----+-----
EUROPE | EUROPE_2011 | FOR VALUES FROM (MINVALUE) TO ('01-JAN-12
00:00:00')
EUROPE | EUROPE_2012 | FOR VALUES FROM ('01-JAN-12 00:00:00') TO ('01-
JAN-13 00:00:00')
ASIA | ASIA_2011 | FOR VALUES FROM (MINVALUE) TO ('01-JAN-12
00:00:00')
ASIA | ASIA_2012 | FOR VALUES FROM ('01-JAN-12 00:00:00') TO ('01-
JAN-13 00:00:00')
AMERICAS | AMERICAS_2011 | FOR VALUES FROM (MINVALUE) TO ('01-JAN-12
00:00:00')
AMERICAS | AMERICAS_2012 | FOR VALUES FROM ('01-JAN-12 00:00:00') TO ('01-
JAN-13 00:00:00')
(6 rows)

```

The following command adds a subpartition named `europe_2013`:

```
ALTER TABLE sales MODIFY PARTITION europe
ADD SUBPARTITION europe_2013
VALUES LESS THAN('2015-Jan-01');
```

After invoking the command, the table includes a subpartition named `europe_2013`:

```
acctg=# SELECT partition_name, subpartition_name, high_value FROM
ALL TAB SUBPARTITIONS;
partition_name | subpartition_name | high_value
-----+-----+-----
EUROPE | EUROPE_2011 | FOR VALUES FROM (MINVALUE) TO ('01-JAN-12
00:00:00')
EUROPE | EUROPE_2012 | FOR VALUES FROM ('01-JAN-12 00:00:00') TO ('01-
JAN-13 00:00:00')
EUROPE | EUROPE_2013 | FOR VALUES FROM ('01-JAN-13 00:00:00') TO ('01-
JAN-15 00:00:00')
ASIA | ASIA_2011 | FOR VALUES FROM (MINVALUE) TO ('01-JAN-12
00:00:00')
ASIA | ASIA_2012 | FOR VALUES FROM ('01-JAN-12 00:00:00') TO ('01-
JAN-13 00:00:00')
AMERICAS | AMERICAS_2011 | FOR VALUES FROM (MINVALUE) TO ('01-JAN-12
00:00:00')
AMERICAS | AMERICAS_2012 | FOR VALUES FROM ('01-JAN-12 00:00:00') TO ('01-
JAN-13 00:00:00')
(7 rows)
```

Note that when adding a new range subpartition, the subpartitioning rules must specify a range that falls *after* any existing subpartitions.

10.3.3.2 Example - Adding a Subpartition to a RANGE-LIST Partitioned Table

The following example adds a LIST subpartition to the RANGE partitioned `sales` table. The `sales` table was created with the command:

```
CREATE TABLE sales
(
    dept_no      number,
    part_no      varchar2,
    country      varchar2(20),
    date         date,
    amount        number
)
PARTITION BY RANGE(date)
SUBPARTITION BY LIST(country)
(
    PARTITION first_half_2012 VALUES LESS THAN('01-JUL-2012')
    (
        SUBPARTITION europe VALUES ('ITALY', 'FRANCE'),
        SUBPARTITION americas VALUES ('US', 'CANADA')
    ),
    PARTITION second_half_2012 VALUES LESS THAN('01-JAN-2013')
    (
        SUBPARTITION asia VALUES ('INDIA', 'PAKISTAN')
```

```
)  
);
```

After executing the above command, the `sales` table will have two partitions, named `first_half_2012` and `second_half_2012`. The `first_half_2012` partition has two subpartitions, named `europe` and `americas`, and the `second_half_2012` partition has one partition, named `asia`:

```
acctg=# SELECT partition_name, subpartition_name, high_value FROM  
ALL_TAB_SUBPARTITIONS;  
partition_name | subpartition_name | high_value  
-----+-----+-----  
FIRST_HALF_2012 | AMERICAS | FOR VALUES IN ('US', 'CANADA')  
FIRST_HALF_2012 | EUROPE | FOR VALUES IN ('ITALY', 'FRANCE')  
SECOND_HALF_2012 | ASIA | FOR VALUES IN ('INDIA', 'PAKISTAN')  
(3 rows)
```

The following command adds a subpartition to the `second_half_2012` partition, named `east_asia`:

```
ALTER TABLE sales MODIFY PARTITION second_half_2012  
ADD SUBPARTITION east_asia VALUES ('CHINA');
```

After invoking the command, the table includes a subpartition named `east_asia`:

```
acctg=# SELECT partition_name, subpartition_name, high_value FROM  
ALL_TAB_SUBPARTITIONS;  
partition_name | subpartition_name | high_value  
-----+-----+-----  
FIRST_HALF_2012 | AMERICAS | FOR VALUES IN ('US', 'CANADA')  
FIRST_HALF_2012 | EUROPE | FOR VALUES IN ('ITALY', 'FRANCE')  
SECOND_HALF_2012 | EAST_ASIA | FOR VALUES IN ('CHINA')  
SECOND_HALF_2012 | ASIA | FOR VALUES IN ('INDIA', 'PAKISTAN')  
(4 rows)
```

10.3.4 ALTER TABLE...SPLIT PARTITION

Use the `ALTER TABLE... SPLIT PARTITION` command to divide a single partition into two partitions, and redistribute the partition's contents between the new partitions. The command syntax comes in two forms.

The first form splits a `RANGE` partition into two partitions:

```
ALTER TABLE table_name SPLIT PARTITION partition_name
  AT (range_part_value)
  INTO
  (
    PARTITION new_part1
      [TABLESPACE tablespace_name],
    PARTITION new_part2
      [TABLESPACE tablespace_name]
  );
;
```

The second form splits a `LIST` partition into two partitions:

```
ALTER TABLE table_name SPLIT PARTITION partition_name
  VALUES (value[, value]...)
  INTO
  (
    PARTITION new_part1
      [TABLESPACE tablespace_name],
    PARTITION new_part2
      [TABLESPACE tablespace_name]
  );
;
```

Description

The `ALTER TABLE... SPLIT PARTITION` command adds a partition to an existing `LIST` or `RANGE` partitioned table. Please note that the `ALTER TABLE... SPLIT PARTITION` command cannot add a partition to a `HASH` partitioned table. There is no upper limit to the number of partitions that a table may have.

When you execute an `ALTER TABLE... SPLIT PARTITION` command, Advanced Server creates two new partitions, and redistributes the content of the old partition between them (as constrained by the partitioning rules).

Include the `TABLESPACE` clause to specify the tablespace in which a partition will reside. If you do not specify a tablespace, the partition will reside in the default tablespace.

If the table is indexed, the index will be created on the new partition.

To use the `ALTER TABLE... SPLIT PARTITION` command you must be the table owner, or have superuser (or administrative) privileges.

Parameters

table_name

The name (optionally schema-qualified) of the partitioned table.

partition_name

The name of the partition that is being split.

new_part1

The name of the first new partition to be created. Partition names must be unique amongst all partitions and subpartitions, and must follow the naming conventions for object identifiers.

new_part1 will receive the rows that meet the partitioning constraints specified in the `ALTER TABLE... SPLIT PARTITION` command.

new_part2

The name of the second new partition to be created. Partition names must be unique amongst all partitions and subpartitions, and must follow the naming conventions for object identifiers.

new_part2 will receive the rows are not directed to *new_part1* by the partitioning constraints specified in the `ALTER TABLE... SPLIT PARTITION` command.

range_part_value

Use *range_part_value* to specify the boundary rules by which to create the new partition. The partitioning rule must contain at least one column of a data type that has two operators (i.e., a greater-than-or-equal to operator, and a less-than operator). Range boundaries are evaluated against a `LESS THAN` clause and are non-inclusive; a date boundary of January 1, 2010 will include only those date values that fall on or before December 31, 2009.

(*value*[, *value*]...)

Use *value* to specify a quoted literal value (or comma-delimited list of literal values) by which rows will be distributed into partitions. Each partitioning rule

must specify at least one value, but there is no limit placed on the number of values specified within a rule.

For information about creating a `DEFAULT` or `MAXVALUE` partition, see Section [10.4](#).

`tablespace_name`

The name of the tablespace in which the partition or subpartition resides.

10.3.4.1 Example - Splitting a LIST Partition

Our example will divide one of the partitions in the list-partitioned `sales` table into two new partitions, and redistribute the contents of the partition between them. The `sales` table is created with the statement:

```
CREATE TABLE sales
(
    dept_no      number,
    part_no      varchar2,
    country      varchar2(20),
    date         date,
    amount        number
)
PARTITION BY LIST(country)
(
    PARTITION europe VALUES ('FRANCE', 'ITALY'),
    PARTITION asia VALUES ('INDIA', 'PAKISTAN'),
    PARTITION americas VALUES('US', 'CANADA')
);
```

The table definition creates three partitions (`europe`, `asia`, and `americas`). The following command adds rows to each partition:

```
INSERT INTO sales VALUES
(10, '4519b', 'FRANCE', '17-Jan-2012', '45000'),
(20, '3788a', 'INDIA', '01-Mar-2012', '75000'),
(40, '9519b', 'US', '12-Apr-2012', '145000'),
(20, '3788a', 'PAKISTAN', '04-Jun-2012', '37500'),
(40, '4577b', 'US', '11-Nov-2012', '25000'),
(30, '7588b', 'CANADA', '14-Dec-2012', '50000'),
(30, '9519b', 'CANADA', '01-Feb-2012', '75000'),
(30, '4519b', 'CANADA', '08-Apr-2012', '120000'),
(40, '3788a', 'US', '12-May-2012', '4950'),
(10, '9519b', 'ITALY', '07-Jul-2012', '15000'),
(10, '9519a', 'FRANCE', '18-Aug-2012', '650000'),
(10, '9519b', 'FRANCE', '18-Aug-2012', '650000'),
(20, '3788b', 'INDIA', '21-Sept-2012', '5090'),
(40, '4788a', 'US', '23-Sept-2012', '4950'),
```

```
(40, '4788b', 'US', '09-Oct-2012', '15000'),
(20, '4519a', 'INDIA', '18-Oct-2012', '650000'),
(20, '4519b', 'INDIA', '2-Dec-2012', '5090');
```

The rows are distributed amongst the partitions:

```
acctg=# SELECT tableoid::regclass, * FROM sales;
   tableoid | dept_no | part_no | country |          date | amount
-----+-----+-----+-----+-----+-----+-----+
sales_americas |    40 | 9519b | US | 12-APR-12 00:00:00 | 145000
sales_americas |    40 | 4577b | US | 11-NOV-12 00:00:00 | 25000
sales_americas |    30 | 7588b | CANADA | 14-DEC-12 00:00:00 | 50000
sales_americas |    30 | 9519b | CANADA | 01-FEB-12 00:00:00 | 75000
sales_americas |    30 | 4519b | CANADA | 08-APR-12 00:00:00 | 120000
sales_americas |    40 | 3788a | US | 12-MAY-12 00:00:00 | 4950
sales_americas |    40 | 4788a | US | 23-SEP-12 00:00:00 | 4950
sales_americas |    40 | 4788b | US | 09-OCT-12 00:00:00 | 15000
sales_europe |    10 | 4519b | FRANCE | 17-JAN-12 00:00:00 | 45000
sales_europe |    10 | 9519b | ITALY | 07-JUL-12 00:00:00 | 15000
sales_europe |    10 | 9519a | FRANCE | 18-AUG-12 00:00:00 | 650000
sales_europe |    10 | 9519b | FRANCE | 18-AUG-12 00:00:00 | 650000
sales_asia |    20 | 3788a | INDIA | 01-MAR-12 00:00:00 | 75000
sales_asia |    20 | 3788a | PAKISTAN | 04-JUN-12 00:00:00 | 37500
sales_asia |    20 | 3788b | INDIA | 21-SEP-12 00:00:00 | 5090
sales_asia |    20 | 4519a | INDIA | 18-OCT-12 00:00:00 | 650000
sales_asia |    20 | 4519b | INDIA | 02-DEC-12 00:00:00 | 5090
(17 rows)
```

The following command splits the americas partition into two partitions named us and canada:

```
ALTER TABLE sales SPLIT PARTITION americas
VALUES ('US')
INTO (PARTITION us, PARTITION canada);
```

A SELECT statement confirms that the rows have been redistributed across the correct partitions:

```
acctg=# SELECT tableoid::regclass, * FROM sales;
   tableoid | dept_no | part_no | country |          date | amount
-----+-----+-----+-----+-----+-----+
sales_canada |    30 | 7588b | CANADA | 14-DEC-12 00:00:00 | 50000
sales_canada |    30 | 9519b | CANADA | 01-FEB-12 00:00:00 | 75000
sales_canada |    30 | 4519b | CANADA | 08-APR-12 00:00:00 | 120000
sales_europe |    10 | 4519b | FRANCE | 17-JAN-12 00:00:00 | 45000
sales_europe |    10 | 9519b | ITALY | 07-JUL-12 00:00:00 | 15000
sales_europe |    10 | 9519a | FRANCE | 18-AUG-12 00:00:00 | 650000
sales_europe |    10 | 9519b | FRANCE | 18-AUG-12 00:00:00 | 650000
sales_asia |    20 | 3788a | INDIA | 01-MAR-12 00:00:00 | 75000
sales_asia |    20 | 3788a | PAKISTAN | 04-JUN-12 00:00:00 | 37500
sales_asia |    20 | 3788b | INDIA | 21-SEP-12 00:00:00 | 5090
sales_asia |    20 | 4519a | INDIA | 18-OCT-12 00:00:00 | 650000
sales_asia |    20 | 4519b | INDIA | 02-DEC-12 00:00:00 | 5090
sales_us |    40 | 9519b | US | 12-APR-12 00:00:00 | 145000
sales_us |    40 | 4577b | US | 11-NOV-12 00:00:00 | 25000
sales_us |    40 | 3788a | US | 12-MAY-12 00:00:00 | 4950
sales_us |    40 | 4788a | US | 23-SEP-12 00:00:00 | 4950
sales_us |    40 | 4788b | US | 09-OCT-12 00:00:00 | 15000
```

(17 rows)

10.3.4.2 Example - Splitting a RANGE Partition

This example divides the `q4_2012` partition (of the range-partitioned `sales` table) into two partitions, and redistribute the partition's contents. Use the following command to create the `sales` table:

```
CREATE TABLE sales
(
    dept_no      number,
    part_no      varchar2,
    country      varchar2(20),
    date         date,
    amount        number
)
PARTITION BY RANGE(date)
(
    PARTITION q1_2012
        VALUES LESS THAN('2012-Apr-01'),
    PARTITION q2_2012
        VALUES LESS THAN('2012-Jul-01'),
    PARTITION q3_2012
        VALUES LESS THAN('2012-Oct-01'),
    PARTITION q4_2012
        VALUES LESS THAN('2013-Jan-01')
);
```

The table definition creates four partitions (`q1_2012`, `q2_2012`, `q3_2012`, and `q4_2012`). The following command adds rows to each partition:

```
INSERT INTO sales VALUES
(10, '4519b', 'FRANCE', '17-Jan-2012', '45000'),
(20, '3788a', 'INDIA', '01-Mar-2012', '75000'),
(40, '9519b', 'US', '12-Apr-2012', '145000'),
(20, '3788a', 'PAKISTAN', '04-Jun-2012', '37500'),
(40, '4577b', 'US', '11-Nov-2012', '25000'),
(30, '7588b', 'CANADA', '14-Dec-2012', '50000'),
(30, '9519b', 'CANADA', '01-Feb-2012', '75000'),
(30, '4519b', 'CANADA', '08-Apr-2012', '120000'),
(40, '3788a', 'US', '12-May-2012', '4950'),
(10, '9519b', 'ITALY', '07-Jul-2012', '15000'),
(10, '9519a', 'FRANCE', '18-Aug-2012', '650000'),
(10, '9519b', 'FRANCE', '18-Aug-2012', '650000'),
(20, '3788b', 'INDIA', '21-Sept-2012', '5090'),
(40, '4788a', 'US', '23-Sept-2012', '4950'),
(40, '4788b', 'US', '09-Oct-2012', '15000'),
(20, '4519a', 'INDIA', '18-Oct-2012', '650000'),
(20, '4519b', 'INDIA', '2-Dec-2012', '5090');
```

A SELECT statement confirms that the rows are distributed amongst the partitions as expected:

```
acctg=# SELECT tableoid::regclass, * FROM sales;
   tableoid | dept_no | part_no | country |          date      | amount
-----+-----+-----+-----+-----+-----+-----+
sales_q1_2012 |    10 | 4519b | FRANCE | 17-JAN-12 00:00:00 | 45000
sales_q1_2012 |    20 | 3788a | INDIA  | 01-MAR-12 00:00:00 | 75000
sales_q1_2012 |    30 | 9519b | CANADA | 01-FEB-12 00:00:00 | 75000
sales_q2_2012 |    40 | 9519b | US     | 12-APR-12 00:00:00 | 145000
sales_q2_2012 |    20 | 3788a | PAKISTAN | 04-JUN-12 00:00:00 | 37500
sales_q2_2012 |    30 | 4519b | CANADA | 08-APR-12 00:00:00 | 120000
sales_q2_2012 |    40 | 3788a | US     | 12-MAY-12 00:00:00 | 4950
sales_q3_2012 |    10 | 9519b | ITALY  | 07-JUL-12 00:00:00 | 15000
sales_q3_2012 |    10 | 9519a | FRANCE | 18-AUG-12 00:00:00 | 650000
sales_q3_2012 |    10 | 9519b | FRANCE | 18-AUG-12 00:00:00 | 650000
sales_q3_2012 |    20 | 3788b | INDIA  | 21-SEP-12 00:00:00 | 5090
sales_q3_2012 |    40 | 4788a | US     | 23-SEP-12 00:00:00 | 4950
sales_q4_2012 |    40 | 4577b | US     | 11-NOV-12 00:00:00 | 25000
sales_q4_2012 |    30 | 7588b | CANADA | 14-DEC-12 00:00:00 | 50000
sales_q4_2012 |    40 | 4788b | US     | 09-OCT-12 00:00:00 | 15000
sales_q4_2012 |    20 | 4519a | INDIA  | 18-OCT-12 00:00:00 | 650000
sales_q4_2012 |    20 | 4519b | INDIA  | 02-DEC-12 00:00:00 | 5090
(17 rows)
```

The following command splits the q4_2012 partition into two partitions named q4_2012_p1 and q4_2012_p2:

```
ALTER TABLE sales SPLIT PARTITION q4_2012
  AT ('15-Nov-2012')
  INTO
  (
    PARTITION q4_2012_p1,
    PARTITION q4_2012_p2
  );
```

A SELECT statement confirms that the rows have been redistributed across the new partitions:

```
acctg=# SELECT tableoid::regclass, * FROM sales;
   tableoid | dept_no | part_no | country |          date      | amount
-----+-----+-----+-----+-----+-----+-----+
sales_q1_2012 |    10 | 4519b | FRANCE | 17-JAN-12 00:00:00 | 45000
sales_q1_2012 |    20 | 3788a | INDIA  | 01-MAR-12 00:00:00 | 75000
sales_q1_2012 |    30 | 9519b | CANADA | 01-FEB-12 00:00:00 | 75000
sales_q2_2012 |    40 | 9519b | US     | 12-APR-12 00:00:00 | 145000
sales_q2_2012 |    20 | 3788a | PAKISTAN | 04-JUN-12 00:00:00 | 37500
sales_q2_2012 |    30 | 4519b | CANADA | 08-APR-12 00:00:00 | 120000
sales_q2_2012 |    40 | 3788a | US     | 12-MAY-12 00:00:00 | 4950
sales_q3_2012 |    10 | 9519b | ITALY  | 07-JUL-12 00:00:00 | 15000
sales_q3_2012 |    10 | 9519a | FRANCE | 18-AUG-12 00:00:00 | 650000
sales_q3_2012 |    10 | 9519b | FRANCE | 18-AUG-12 00:00:00 | 650000
sales_q3_2012 |    20 | 3788b | INDIA  | 21-SEP-12 00:00:00 | 5090
sales_q3_2012 |    40 | 4788a | US     | 23-SEP-12 00:00:00 | 4950
sales_q4_2012_p1 |    40 | 4577b | US     | 11-NOV-12 00:00:00 | 25000
sales_q4_2012_p1 |    40 | 4788b | US     | 09-OCT-12 00:00:00 | 15000
sales_q4_2012_p1 |    20 | 4519a | INDIA  | 18-OCT-12 00:00:00 | 650000
sales_q4_2012_p1 |    20 | 4519b | INDIA  | 02-DEC-12 00:00:00 | 5090
```

Database Compatibility for Oracle® Developers Guide

```
sales_q4_2012_p2 |      30 | 7588b    | CANADA   | 14-DEC-12 00:00:00 | 50000
sales_q4_2012_p2 |      20 | 4519b    | INDIA    | 02-DEC-12 00:00:00 | 5090
(17 rows)
```

10.3.5 ALTER TABLE...SPLIT SUBPARTITION

Use the `ALTER TABLE... SPLIT SUBPARTITION` command to divide a single subpartition into two subpartitions, and redistribute the subpartition's contents. The command comes in two variations.

The first variation splits a range subpartition into two subpartitions:

```
ALTER TABLE table_name SPLIT SUBPARTITION subpartition_name
  AT (range_part_value)
  INTO
  (
    SUBPARTITION new_subpart1
      [TABLESPACE tablespace_name] ,
    SUBPARTITION new_subpart2
      [TABLESPACE tablespace_name]
  );
;
```

The second variation splits a list subpartition into two subpartitions:

```
ALTER TABLE table_name SPLIT SUBPARTITION subpartition_name
  VALUES (value[, value]...)
  INTO
  (
    SUBPARTITION new_subpart1
      [TABLESPACE tablespace_name] ,
    SUBPARTITION new_subpart2
      [TABLESPACE tablespace_name]
  );
;
```

Description

The `ALTER TABLE... SPLIT SUBPARTITION` command adds a subpartition to an existing subpartitioned table. There is no upper limit to the number of defined subpartitions. When you execute an `ALTER TABLE... SPLIT SUBPARTITION` command, Advanced Server creates two new subpartitions, moving any rows that contain values that are constrained by the specified subpartition rules into *new_subpart1*, and any remaining rows into *new_subpart2*.

The new subpartition rules must reference the column specified in the rules that define the existing subpartition(s).

Include the `TABLESPACE` clause to specify a tablespace in which a new subpartition will reside. If you do not specify a tablespace, the subpartition will be created in the default tablespace.

If the table is indexed, the index will be created on the new subpartition.

To use the `ALTER TABLE... SPLIT SUBPARTITION` command you must be the table owner, or have superuser (or administrative) privileges.

Parameters

table_name

The name (optionally schema-qualified) of the partitioned table.

subpartition_name

The name of the subpartition that is being split.

new_subpart1

The name of the first new subpartition to be created. Subpartition names must be unique amongst all partitions and subpartitions, and must follow the naming conventions for object identifiers.

new_subpart1 will receive the rows that meet the subpartitioning constraints specified in the `ALTER TABLE... SPLIT SUBPARTITION` command.

new_subpart2

The name of the second new subpartition to be created. Subpartition names must be unique amongst all partitions and subpartitions, and must follow the naming conventions for object identifiers.

new_subpart2 will receive the rows are not directed to *new_subpart1* by the subpartitioning constraints specified in the `ALTER TABLE... SPLIT SUBPARTITION` command.

(*value*[, *value*]...)

Use *value* to specify a quoted literal value (or comma-delimited list of literal values) by which table entries will be grouped into partitions. Each partitioning rule must specify at least one value, but there is no limit placed on the number of values specified within a rule. *value* may also be `NULL`, `DEFAULT` (if specifying a `LIST` subpartition), or `MAXVALUE` (if specifying a `RANGE` subpartition).

For information about creating a `DEFAULT` or `MAXVALUE` partition, see Section [10.4](#).

tablespace_name

The name of the tablespace in which the partition or subpartition resides.

10.3.5.1 Example - Splitting a LIST Subpartition

The following example splits a list subpartition, redistributing the subpartition's contents between two new subpartitions. The sample table (`sales`) was created with the command:

```
CREATE TABLE sales
(
    dept_no      number,
    part_no      varchar2,
    country      varchar2(20),
    date         date,
    amount        number
)
PARTITION BY RANGE(date)
    SUBPARTITION BY LIST(country)
    (
        PARTITION first_half_2012 VALUES LESS THAN ('01-JUL-2012')
        (
            SUBPARTITION p1_europe VALUES ('ITALY', 'FRANCE'),
            SUBPARTITION p1_americas VALUES ('US', 'CANADA')
        ),
        PARTITION second_half_2012 VALUES LESS THAN ('01-JAN-2013')
        (
            SUBPARTITION p2_europe VALUES ('ITALY', 'FRANCE'),
            SUBPARTITION p2_americas VALUES ('US', 'CANADA')
        )
    );
);
```

The `sales` table has two partitions, named `first_half_2012`, and `second_half_2012`. Each partition has two range-defined subpartitions that distribute the partition's contents into subpartitions based on the value of the `country` column:

partition_name	subpartition_name	high_value
FIRST_HALF_2012	P1_AMERICAS	FOR VALUES IN ('US', 'CANADA')
FIRST_HALF_2012	P1_EUROPE	FOR VALUES IN ('ITALY', 'FRANCE')
SECOND_HALF_2012	P2_AMERICAS	FOR VALUES IN ('US', 'CANADA')
SECOND_HALF_2012	P2_EUROPE	FOR VALUES IN ('ITALY', 'FRANCE')

The following command adds rows to each subpartition:

```
INSERT INTO sales VALUES
(10, '4519b', 'FRANCE', '17-Jan-2012', '45000'),
(40, '9519b', 'US', '12-Apr-2012', '145000'),
(40, '4577b', 'US', '11-Nov-2012', '25000'),
(30, '7588b', 'CANADA', '14-Dec-2012', '50000'),
(30, '9519b', 'CANADA', '01-Feb-2012', '75000'),
(30, '4519b', 'CANADA', '08-Apr-2012', '120000'),
(40, '3788a', 'US', '12-May-2012', '4950'),
(10, '9519b', 'ITALY', '07-Jul-2012', '15000'),
(10, '9519a', 'FRANCE', '18-Aug-2012', '650000'),
(10, '9519b', 'FRANCE', '18-Aug-2012', '650000'),
(40, '4788a', 'US', '23-Sept-2012', '4950'),
(40, '4788b', 'US', '09-Oct-2012', '15000);
```

A SELECT statement confirms that the rows are correctly distributed amongst the subpartitions:

```
acctg=# SELECT tableoid::regclass, * FROM sales;
   tableoid | dept_no | part_no | country |      date      | amount
-----+-----+-----+-----+-----+-----+
sales_p1_americas |    40 | 9519b | US     | 12-APR-12 00:00:00 | 145000
sales_p1_americas |    30 | 9519b | CANADA | 01-FEB-12 00:00:00 | 75000
sales_p1_americas |    30 | 4519b | CANADA | 08-APR-12 00:00:00 | 120000
sales_p1_americas |    40 | 3788a | US     | 12-MAY-12 00:00:00 | 4950
sales_p1_europe   |    10 | 4519b | FRANCE | 17-JAN-12 00:00:00 | 45000
sales_p2_americas |    40 | 4577b | US     | 11-NOV-12 00:00:00 | 25000
sales_p2_americas |    30 | 7588b | CANADA | 14-DEC-12 00:00:00 | 50000
sales_p2_americas |    40 | 4788a | US     | 23-SEP-12 00:00:00 | 4950
sales_p2_americas |    40 | 4788b | US     | 09-OCT-12 00:00:00 | 15000
sales_p2_europe   |    10 | 9519b | ITALY   | 07-JUL-12 00:00:00 | 15000
sales_p2_europe   |    10 | 9519a | FRANCE | 18-AUG-12 00:00:00 | 650000
sales_p2_europe   |    10 | 9519b | FRANCE | 18-AUG-12 00:00:00 | 650000
(12 rows)
```

The following command splits the p2_americas subpartition into two new subpartitions, and redistributes the contents:

```
ALTER TABLE sales SPLIT SUBPARTITION p2_americas
VALUES ('US')
INTO
(
    SUBPARTITION p2_us,
    SUBPARTITION p2_canada
);
```

After invoking the command, the p2_americas subpartition has been deleted; in its place, the server has created two new subpartitions (p2_us and p2_canada):

```
acctg=# SELECT partition_name, subpartition_name, high_value FROM
ALL_TAB_SUBPARTITIONS;
   partition_name | subpartition_name |          high_value
-----+-----+-----+
FIRST_HALF_2012 | P1_AMERICAS    | FOR VALUES IN ('US', 'CANADA')
FIRST_HALF_2012 | P1_EUROPE      | FOR VALUES IN ('ITALY', 'FRANCE')
SECOND_HALF_2012 | P2_CANADA      | FOR VALUES IN ('CANADA')
```

```
SECOND_HALF_2012 | P2_US           | FOR VALUES IN ('US')
SECOND_HALF_2012 | P2_EUROPE      | FOR VALUES IN ('ITALY', 'FRANCE')
(5 rows)
```

Querying the `sales` table demonstrates that the content of the `p2_americas` subpartition has been redistributed:

```
acctg=# SELECT tableoid::regclass, * FROM sales;
   tableoid | dept_no | part_no | country |          date       | amount
-----+-----+-----+-----+-----+-----+-----+
sales_p1_americas |    40 | 9519b | US     | 12-APR-12 00:00:00 | 145000
sales_p1_americas |    30 | 9519b | CANADA | 01-FEB-12 00:00:00 | 75000
sales_p1_americas |    30 | 4519b | CANADA | 08-APR-12 00:00:00 | 120000
sales_p1_americas |    40 | 3788a | US     | 12-MAY-12 00:00:00 | 4950
sales_p1_europe   |    10 | 4519b | FRANCE | 17-JAN-12 00:00:00 | 45000
sales_p2_canada  |    30 | 7588b | CANADA | 14-DEC-12 00:00:00 | 50000
sales_p2_europe   |    10 | 9519b | ITALY   | 07-JUL-12 00:00:00 | 15000
sales_p2_europe   |    10 | 9519a | FRANCE | 18-AUG-12 00:00:00 | 650000
sales_p2_europe   |    10 | 9519b | FRANCE | 18-AUG-12 00:00:00 | 650000
sales_p2_us        |    40 | 4577b | US     | 11-NOV-12 00:00:00 | 25000
sales_p2_us        |    40 | 4788a | US     | 23-SEP-12 00:00:00 | 4950
sales_p2_us        |    40 | 4788b | US     | 09-OCT-12 00:00:00 | 15000
(12 rows)
```

10.3.5.2 Example - Splitting a RANGE Subpartition

The following example splits a range subpartition, redistributing the subpartition's contents between two new subpartitions. The sample table (`sales`) was created with the command:

```
CREATE TABLE sales
(
  dept_no      number,
  part_no      varchar2,
  country      varchar2(20),
  date         date,
  amount        number
)
PARTITION BY LIST(country)
  SUBPARTITION BY RANGE(date)
(
  PARTITION europe VALUES('FRANCE', 'ITALY')
  (
    SUBPARTITION europe_2011
      VALUES LESS THAN('2012-Jan-01'),
    SUBPARTITION europe_2012
      VALUES LESS THAN('2013-Jan-01')
  ),
  PARTITION asia VALUES('INDIA', 'PAKISTAN')
  (
    SUBPARTITION asia_2011
      VALUES LESS THAN('2012-Jan-01'),
```

```

        SUBPARTITION asia_2012
          VALUES LESS THAN('2013-Jan-01')
      ),
PARTITION americas VALUES('US', 'CANADA')
(
    SUBPARTITION americas_2011
      VALUES LESS THAN('2012-Jan-01'),
    SUBPARTITION americas_2012
      VALUES LESS THAN('2013-Jan-01')
)
);

```

The `sales` table has three partitions (`europe`, `asia`, and `americas`). Each partition has two range-defined subpartitions that sort the partitions contents into subpartitions by the value of the `date` column:

```

acctg=# SELECT partition_name, subpartition_name, high_value FROM
ALL_TAB_SUBPARTITIONS;
partition_name | subpartition_name | high_value
-----+-----+-----
-----+
EUROPE | EUROPE_2012 | FOR VALUES FROM ('01-JAN-12 00:00:00') TO ('01-
JAN-13 00:00:00')
EUROPE | EUROPE_2011 | FOR VALUES FROM (MINVALUE) TO ('01-JAN-12
00:00:00')
ASIA | ASIA_2012 | FOR VALUES FROM ('01-JAN-12 00:00:00') TO ('01-
JAN-13 00:00:00')
ASIA | ASIA_2011 | FOR VALUES FROM (MINVALUE) TO ('01-JAN-12
00:00:00')
AMERICAS | AMERICAS_2012 | FOR VALUES FROM ('01-JAN-12 00:00:00') TO ('01-
JAN-13 00:00:00')
AMERICAS | AMERICAS_2011 | FOR VALUES FROM (MINVALUE) TO ('01-JAN-12
00:00:00')
(6 rows)

```

The following command adds rows to each subpartition:

```

INSERT INTO sales VALUES
(10, '4519b', 'FRANCE', '17-Jan-2012', '45000'),
(20, '3788a', 'INDIA', '01-Mar-2012', '75000'),
(40, '9519b', 'US', '12-Apr-2012', '145000'),
(20, '3788a', 'PAKISTAN', '04-Jun-2012', '37500'),
(40, '4577b', 'US', '11-Nov-2012', '25000'),
(30, '7588b', 'CANADA', '14-Dec-2012', '50000'),
(30, '9519b', 'CANADA', '01-Feb-2012', '75000'),
(30, '4519b', 'CANADA', '08-Apr-2012', '120000'),
(40, '3788a', 'US', '12-May-2012', '4950'),
(10, '9519b', 'ITALY', '07-Jul-2012', '15000'),
(10, '9519a', 'FRANCE', '18-Aug-2012', '650000'),
(10, '9519b', 'FRANCE', '18-Aug-2012', '650000'),
(20, '3788b', 'INDIA', '21-Sept-2012', '5090'),
(40, '4788a', 'US', '23-Sept-2012', '4950'),
(40, '4788b', 'US', '09-Oct-2012', '15000'),
(20, '4519a', 'INDIA', '18-Oct-2012', '650000'),
(20, '4519b', 'INDIA', '2-Dec-2012', '5090');

```

A SELECT statement confirms that the rows are distributed amongst the subpartitions:

```
acctg=# SELECT tableoid::regclass, * FROM sales;
   tableoid | dept_no | part_no | country |      date      | amount
-----+-----+-----+-----+-----+-----+
sales_americas_2012 |    40 | 9519b | US | 12-APR-12 00:00:00 | 145000
sales_americas_2012 |    40 | 4577b | US | 11-NOV-12 00:00:00 | 25000
sales_americas_2012 |    30 | 7588b | CANADA | 14-DEC-12 00:00:00 | 50000
sales_americas_2012 |    30 | 9519b | CANADA | 01-FEB-12 00:00:00 | 75000
sales_americas_2012 |    30 | 4519b | CANADA | 08-APR-12 00:00:00 | 120000
sales_americas_2012 |    40 | 3788a | US | 12-MAY-12 00:00:00 | 4950
sales_americas_2012 |    40 | 4788a | US | 23-SEP-12 00:00:00 | 4950
sales_americas_2012 |    40 | 4788b | US | 09-OCT-12 00:00:00 | 15000
sales_europe_2012 |    10 | 4519b | FRANCE | 17-JAN-12 00:00:00 | 45000
sales_europe_2012 |    10 | 9519b | ITALY | 07-JUL-12 00:00:00 | 15000
sales_europe_2012 |    10 | 9519a | FRANCE | 18-AUG-12 00:00:00 | 650000
sales_europe_2012 |    10 | 9519b | FRANCE | 18-AUG-12 00:00:00 | 650000
sales_asia_2012 |    20 | 3788a | INDIA | 01-MAR-12 00:00:00 | 75000
sales_asia_2012 |    20 | 3788a | PAKISTAN | 04-JUN-12 00:00:00 | 37500
sales_asia_2012 |    20 | 3788b | INDIA | 21-SEP-12 00:00:00 | 5090
sales_asia_2012 |    20 | 4519a | INDIA | 18-OCT-12 00:00:00 | 650000
sales_asia_2012 |    20 | 4519b | INDIA | 02-DEC-12 00:00:00 | 5090
(17 rows)
```

The following command splits the `americas_2012` subpartition into two new subpartitions, and redistributes the contents:

```
ALTER TABLE sales
  SPLIT SUBPARTITION americas_2012
  AT ('2012-Jun-01')
  INTO
  (
    SUBPARTITION americas_p1_2012,
    SUBPARTITION americas_p2_2012
  );
```

After invoking the command, the `americas_2012` subpartition has been deleted; in its place, the server has created two new subpartitions (`americas_p1_2012` and `americas_p2_2012`):

```
acctg=# SELECT partition_name, subpartition_name, high_value FROM
ALL_TAB_SUBPARTITIONS;
   partition_name | subpartition_name | high_value
-----+-----+-----+
EUROPE | EUROPE_2011 | FOR VALUES FROM (MINVALUE) TO ('01-JAN-12
00:00:00')
EUROPE | EUROPE_2012 | FOR VALUES FROM ('01-JAN-12 00:00:00') TO ('01-
JAN-13 00:00:00')
ASIA | ASIA_2011 | FOR VALUES FROM (MINVALUE) TO ('01-JAN-12
00:00:00')
ASIA | ASIA_2012 | FOR VALUES FROM ('01-JAN-12 00:00:00') TO ('01-
JAN-13 00:00:00')
AMERICAS | AMERICAS_2011 | FOR VALUES FROM (MINVALUE) TO ('01-JAN-12
00:00:00')
AMERICAS | AMERICAS_P1_2012 | FOR VALUES FROM ('01-JAN-12 00:00:00') TO ('01-
JUN-12 00:00:00')
AMERICAS | AMERICAS_P2_2012 | FOR VALUES FROM ('01-JUN-12 00:00:00') TO ('01-
JAN-13 00:00:00')
(7 rows)
```

Querying the `sales` table demonstrates that the subpartition's contents are redistributed:

```
acctg=# SELECT tableoid::regclass, * FROM sales;
   tableoid | dept_no | part_no | country |      date      | amount
-----+-----+-----+-----+-----+-----+
sales_americas_p1_2012 |    40 | 9519b | US      | 12-APR-12 00:00:00 | 145000
sales_americas_p1_2012 |    30 | 9519b | CANADA  | 01-FEB-12 00:00:00 | 75000
sales_americas_p1_2012 |    30 | 4519b | CANADA  | 08-APR-12 00:00:00 | 120000
sales_americas_p1_2012 |    40 | 3788a | US      | 12-MAY-12 00:00:00 | 4950
sales_americas_p2_2012 |    40 | 4577b | US      | 11-NOV-12 00:00:00 | 25000
sales_americas_p2_2012 |    30 | 7588b | CANADA  | 14-DEC-12 00:00:00 | 50000
sales_americas_p2_2012 |    40 | 4788a | US      | 23-SEP-12 00:00:00 | 4950
sales_americas_p2_2012 |    40 | 4788b | US      | 09-OCT-12 00:00:00 | 15000
sales_europe_2012      |    10 | 4519b | FRANCE  | 17-JAN-12 00:00:00 | 45000
sales_europe_2012      |    10 | 9519b | ITALY   | 07-JUL-12 00:00:00 | 15000
sales_europe_2012      |    10 | 9519a | FRANCE  | 18-AUG-12 00:00:00 | 650000
sales_europe_2012      |    10 | 9519b | FRANCE  | 18-AUG-12 00:00:00 | 650000
sales_asia_2012        |    20 | 3788a | INDIA   | 01-MAR-12 00:00:00 | 75000
sales_asia_2012        |    20 | 3788a | PAKISTAN | 04-JUN-12 00:00:00 | 37500
sales_asia_2012        |    20 | 3788b | INDIA   | 21-SEP-12 00:00:00 | 5090
sales_asia_2012        |    20 | 4519a | INDIA   | 18-OCT-12 00:00:00 | 650000
sales_asia_2012        |    20 | 4519b | INDIA   | 02-DEC-12 00:00:00 | 5090
(17 rows)
```

10.3.6 ALTER TABLE... EXCHANGE PARTITION

The `ALTER TABLE...EXCHANGE PARTITION` command swaps an existing table with a partition. If you plan to add a large quantity of data to a partitioned table, you can use the `ALTER TABLE... EXCHANGE PARTITION` command to implement a bulk load. You can also use the `ALTER TABLE... EXCHANGE PARTITION` command to remove old or unneeded data for storage.

The command syntax is available in two forms.

The first form swaps a table for a partition:

```
ALTER TABLE target_table
    EXCHANGE PARTITION target_partition
        WITH TABLE source_table
            [(INCLUDING | EXCLUDING) INDEXES]
            [(WITH | WITHOUT) VALIDATION];
```

The second form swaps a table for a subpartition:

```
ALTER TABLE target_table
    EXCHANGE SUBPARTITION target_subpartition
        WITH TABLE source_table
            [(INCLUDING | EXCLUDING) INDEXES]
            [(WITH | WITHOUT) VALIDATION];
```

Description

When the `ALTER TABLE...EXCHANGE PARTITION` command completes, the data originally located in the *target_partition* will be located in the *source_table*, and the data originally located in the *source_table* will be located in the *target_partition*.

The `ALTER TABLE... EXCHANGE PARTITION` command can exchange partitions in a LIST, RANGE or HASH partitioned table. The structure of the *source_table* must match the structure of the *target_table* (both tables must have matching columns and data types), and the data contained within the table must adhere to the partitioning constraints.

If the `INCLUDING INDEXES` clause is specified with `EXCHANGE PARTITION`, then matching indexes in the *target_partition* and *source_table* are swapped. Indexes in the *target_partition* with no match in the *source_table* are rebuilt and vice versa (that is, indexes in the *source_table* with no match in the *target_partition* are also rebuilt).

If the EXCLUDING INDEXES clause is specified with EXCHANGE PARTITION, then matching indexes in the *target_partition* and *source_table* are swapped, but the *target_partition* indexes with no match in the *source_table* are marked as invalid and vice versa (that is, indexes in the *source_table* with no match in the *target_partition* are also marked as invalid).

The previously used *matching index* term refers to indexes that have the same attributes such as the collation order, ascending or descending direction, ordering of nulls first or nulls last, and so forth as determined by the CREATE INDEX command.

If both INCLUDING INDEXES and EXCLUDING INDEXES are omitted, then the default action is the EXCLUDING INDEXES behavior.

The same behavior as previously described applies for the *target_subpartition* used with the EXCHANGE SUBPARTITION clause.

You must own a table to invoke ALTER TABLE... EXCHANGE PARTITION or ALTER TABLE... EXCHANGE SUBPARTITION against that table.

Parameters:

target_table

The name (optionally schema-qualified) of the table in which the partition or subpartition resides.

target_partition

The name of the partition to be replaced.

target_subpartition

The name of the subpartition to be replaced.

source_table

The name of the table that will replace the *target_partition* or *target_subpartition*.

10.3.6.1 Example - Exchanging a Table for a Partition

The example that follows demonstrates swapping a table for a partition (*americas*) of the *sales* table. You can create the *sales* table with the following command:

```

CREATE TABLE sales
(
    dept_no      number,
    part_no      varchar2,
    country      varchar2(20),
    date         date,
    amount       number
)
PARTITION BY LIST(country)
(
    PARTITION europe VALUES('FRANCE', 'ITALY'),
    PARTITION asia VALUES('INDIA', 'PAKISTAN'),
    PARTITION americas VALUES('US', 'CANADA')
);

```

Use the following command to add sample data to the `sales` table:

```

INSERT INTO sales VALUES
(40, '9519b', 'US', '12-Apr-2012', '145000'),
(10, '4519b', 'FRANCE', '17-Jan-2012', '45000'),
(20, '3788a', 'INDIA', '01-Mar-2012', '75000'),
(20, '3788a', 'PAKISTAN', '04-Jun-2012', '37500'),
(10, '9519b', 'ITALY', '07-Jul-2012', '15000'),
(10, '9519a', 'FRANCE', '18-Aug-2012', '650000'),
(10, '9519b', 'FRANCE', '18-Aug-2012', '650000'),
(20, '3788b', 'INDIA', '21-Sept-2012', '5090'),
(20, '4519a', 'INDIA', '18-Oct-2012', '650000'),
(20, '4519b', 'INDIA', '2-Dec-2012', '5090');

```

Querying the `sales` table shows that only one row resides in the `americas` partition:

SELECT tableoid::regclass, * FROM sales;						
tableoid	dept_no	part_no	country	date	amount	
sales_americas	40	9519b	US	12-APR-12 00:00:00	145000	
sales_europe	10	4519b	FRANCE	17-JAN-12 00:00:00	45000	
sales_europe	10	9519b	ITALY	07-JUL-12 00:00:00	15000	
sales_europe	10	9519a	FRANCE	18-AUG-12 00:00:00	650000	
sales_europe	10	9519b	FRANCE	18-AUG-12 00:00:00	650000	
sales_asia	20	3788a	INDIA	01-MAR-12 00:00:00	75000	
sales_asia	20	3788a	PAKISTAN	04-JUN-12 00:00:00	37500	
sales_asia	20	3788b	INDIA	21-SEP-12 00:00:00	5090	
sales_asia	20	4519a	INDIA	18-OCT-12 00:00:00	650000	
sales_asia	20	4519b	INDIA	02-DEC-12 00:00:00	5090	
(10 rows)						

The following command creates a table (`n_america`) that matches the definition of the `sales` table:

```

CREATE TABLE n_america
(
    dept_no      number,
    part_no      varchar2,

```

```

country      varchar2(20),
date        date,
amount      number
);

```

The following command adds data to the `n_americas` table. The data conforms to the partitioning rules of the `americas` partition:

```

INSERT INTO n_americas VALUES
(40, '9519b', 'US', '12-Apr-2012', '145000'),
(40, '4577b', 'US', '11-Nov-2012', '25000'),
(30, '7588b', 'CANADA', '14-Dec-2012', '50000'),
(30, '9519b', 'CANADA', '01-Feb-2012', '75000'),
(30, '4519b', 'CANADA', '08-Apr-2012', '120000'),
(40, '3788a', 'US', '12-May-2012', '4950'),
(40, '4788a', 'US', '23-Sept-2012', '4950'),
(40, '4788b', 'US', '09-Oct-2012', '15000');

```

The following command swaps the table into the partitioned table:

```

ALTER TABLE sales
EXCHANGE PARTITION americas
WITH TABLE n_americas;

```

Querying the `sales` table shows that the contents of the `n_americas` table has been exchanged for the content of the `americas` partition:

```

acctg=# SELECT tableoid::regclass, * FROM sales;
   tableoid | dept_no | part_no | country |          date       | amount
-----+-----+-----+-----+-----+-----+-----+
sales_americas |    40 | 9519b | US | 12-APR-12 00:00:00 | 145000
sales_americas |    40 | 4577b | US | 11-NOV-12 00:00:00 | 25000
sales_americas |    30 | 7588b | CANADA | 14-DEC-12 00:00:00 | 50000
sales_americas |    30 | 9519b | CANADA | 01-FEB-12 00:00:00 | 75000
sales_americas |    30 | 4519b | CANADA | 08-APR-12 00:00:00 | 120000
sales_americas |    40 | 3788a | US | 12-MAY-12 00:00:00 | 4950
sales_americas |    40 | 4788a | US | 23-SEP-12 00:00:00 | 4950
sales_americas |    40 | 4788b | US | 09-OCT-12 00:00:00 | 15000
sales_europe |    10 | 4519b | FRANCE | 17-JAN-12 00:00:00 | 45000
sales_europe |    10 | 9519b | ITALY | 07-JUL-12 00:00:00 | 15000
sales_europe |    10 | 9519a | FRANCE | 18-AUG-12 00:00:00 | 650000
sales_europe |    10 | 9519b | FRANCE | 18-AUG-12 00:00:00 | 650000
sales_asia |    20 | 3788a | INDIA | 01-MAR-12 00:00:00 | 75000
sales_asia |    20 | 3788a | PAKISTAN | 04-JUN-12 00:00:00 | 37500
sales_asia |    20 | 3788b | INDIA | 21-SEP-12 00:00:00 | 5090
sales_asia |    20 | 4519a | INDIA | 18-OCT-12 00:00:00 | 650000
sales_asia |    20 | 4519b | INDIA | 02-DEC-12 00:00:00 | 5090
(17 rows)

```

Querying the `n_americas` table shows that the row that was previously stored in the `americas` partition has been moved to the `n_americas` table:

```

acctg=# SELECT tableoid::regclass, * FROM n_americas;
   tableoid | dept_no | part_no | country |          date       | amount
-----+-----+-----+-----+-----+-----+

```

Database Compatibility for Oracle® Developers Guide

n_america 40 9519b US 12-APR-12 00:00:00 145000
(1 row)

10.3.7 ALTER TABLE... MOVE PARTITION

Use the `ALTER TABLE... MOVE PARTITION` command to move a partition to a different tablespace. The command takes two forms.

The first form moves a partition to a new tablespace:

```
ALTER TABLE table_name
MOVE PARTITION partition_name
TABLESPACE tablespace_name;
```

The second form moves a subpartition to a new tablespace:

```
ALTER TABLE table_name
MOVE SUBPARTITION subpartition_name
TABLESPACE tablespace_name;
```

Description

The `ALTER TABLE...MOVE PARTITION` command moves a partition from its current tablespace to a different tablespace. The `ALTER TABLE...MOVE PARTITION` command can move partitions of a LIST, RANGE or HASH partitioned table.

The same behavior as previously described applies for the `subpartition_name` used with the `MOVE SUBPARTITION` clause.

You must own the table to invoke `ALTER TABLE... MOVE PARTITION` or `ALTER TABLE... MOVE SUBPARTITION`.

Parameters

table_name

The name (optionally schema-qualified) of the table in which the partition or subpartition resides.

partition_name

The name of the partition to be moved.

subpartition_name

The name of the subpartition to be moved.

tablespace_name

The name of the tablespace to which the partition or subpartition will be moved.

10.3.7.1 Example - Moving a Partition to a Different Tablespace

The following example moves a partition of the `sales` table from one tablespace to another. First, create the `sales` table with the command:

```
CREATE TABLE sales
(
    dept_no      number,
    part_no      varchar2,
    country      varchar2(20),
    date         date,
    amount       number
)
PARTITION BY RANGE(date)
(
    PARTITION q1_2012 VALUES LESS THAN ('2012-Apr-01'),
    PARTITION q2_2012 VALUES LESS THAN ('2012-Jul-01'),
    PARTITION q3_2012 VALUES LESS THAN ('2012-Oct-01'),
    PARTITION q4_2012 VALUES LESS THAN ('2013-Jan-01') TABLESPACE ts_1,
    PARTITION q1_2013 VALUES LESS THAN ('2013-Mar-01') TABLESPACE ts_2
);
```

Querying the `ALL_TAB_PARTITIONS` view confirms that the partitions reside on the expected servers and tablespaces:

partition_name	tablespace_name
Q1_2012	
Q2_2012	
Q3_2012	
Q4_2012	TS_1
Q1_2013	TS_2

(5 rows)

After preparing the targettablespace, invoke the `ALTER TABLE...MOVE PARTITION` command to move the `q1_2013` partition from a tablespace named `ts_2` to a tablespace named `ts_3`:

```
ALTER TABLE sales MOVE PARTITION q1_2013 TABLESPACE ts_3;
```

Querying the `ALL_TAB_PARTITIONS` view shows that the move was successful:

partition_name	tablespace_name
----------------	-----------------

partition_name		tablespace_name
Q1_2012		
Q2_2012		
Q3_2012		
Q4_2012		TS_1
Q1_2013		TS_3
(5 rows)		

10.3.8 ALTER TABLE... RENAME PARTITION

Use the `ALTER TABLE... RENAME PARTITION` command to rename a table partition. The syntax takes two forms.

The first form renames a partition:

```
ALTER TABLE table_name
  RENAME PARTITION partition_name
    TO new_name;
```

The second form renames a subpartition:

```
ALTER TABLE table_name
  RENAME SUBPARTITION subpartition_name
    TO new_name;
```

Description

The `ALTER TABLE... RENAME PARTITION` command renames a partition.

The same behavior as previously described applies for the `subpartition_name` used with the `RENAME SUBPARTITION` clause.

You must own the specified table to invoke `ALTER TABLE... RENAME PARTITION` or `ALTER TABLE... RENAME SUBPARTITION`.

Parameters

table_name

The name (optionally schema-qualified) of the table in which the partition or subpartition resides.

partition_name

The name of the partition to be renamed.

subpartition_name

The name of the subpartition to be renamed.

new_name

The new name of the partition or subpartition.

10.3.8.1 Example - Renaming a Partition

The following command creates a list-partitioned table named `sales`:

```
CREATE TABLE sales
(
    dept_no      number,
    part_no      varchar2,
    country      varchar2(20),
    date         date,
    amount       number
)
PARTITION BY LIST(country)
(
    PARTITION europe VALUES ('FRANCE', 'ITALY'),
    PARTITION asia VALUES('INDIA', 'PAKISTAN'),
    PARTITION americas VALUES('US', 'CANADA')
);
```

Query the `ALL_TAB_PARTITIONS` view to display the partition names:

```
acctg=# SELECT partition_name, high_value FROM ALL_TAB_PARTITIONS;
partition_name | high_value
-----+-----
EUROPE        | FOR VALUES IN ('FRANCE', 'ITALY')
ASIA          | FOR VALUES IN ('INDIA', 'PAKISTAN')
AMERICAS      | FOR VALUES IN ('US', 'CANADA')
(3 rows)
```

The following command renames the `americas` partition to `n_america`:

```
ALTER TABLE sales
    RENAME PARTITION americas TO n_america;
```

Querying the `ALL_TAB_PARTITIONS` view demonstrates that the partition has been successfully renamed:

```
acctg=# SELECT partition_name, high_value FROM ALL_TAB_PARTITIONS;
partition_name | high_value
-----+-----
EUROPE        | FOR VALUES IN ('FRANCE', 'ITALY')
ASIA          | FOR VALUES IN ('INDIA', 'PAKISTAN')
N_AMERICA     | FOR VALUES IN ('US', 'CANADA')
(3 rows)
```

10.3.9 DROP TABLE

Use the PostgreSQL `DROP TABLE` command to remove a partitioned table definition, its partitions and subpartitions, and delete the table contents. The syntax is:

```
DROP TABLE table_name
```

Parameters

table_name

The name (optionally schema-qualified) of the partitioned table.

Description

The `DROP TABLE` command removes an entire table, and the data that resides in that table. When you delete a table, any partitions or subpartitions (of that table) are deleted as well.

To use the `DROP TABLE` command, you must be the owner of the partitioning root, a member of a group that owns the table, the schema owner, or a database superuser.

Example

To delete a table, connect to the controller node (the host of the partitioning root), and invoke the `DROP TABLE` command. For example, to delete the `sales` table, invoke the following command:

```
DROP TABLE sales;
```

The server will confirm that the table has been dropped:

```
acctg=# drop table sales;
DROP TABLE
acctg=
```

For more information about the `DROP TABLE` command, please see the PostgreSQL core documentation at:

<https://www.postgresql.org/docs/10/static/sql-droptable.html>

10.3.10 ALTER TABLE... DROP PARTITION

Use the `ALTER TABLE... DROP PARTITION` command to delete a partition definition, and the data stored in that partition. The syntax is:

```
ALTER TABLE table_name DROP PARTITION partition_name;
```

Parameters

table_name

The name (optionally schema-qualified) of the partitioned table.

partition_name

The name of the partition to be deleted.

Description

The `ALTER TABLE... DROP PARTITION` command deletes a partition and any data stored on that partition. The `ALTER TABLE... DROP PARTITION` command can drop partitions of a `LIST` or `RANGE` partitioned table; please note that this command does not work on a `HASH` partitioned table. When you delete a partition, any subpartitions (of that partition) are deleted as well.

To use the `DROP PARTITION` clause, you must be the owner of the partitioning root, a member of a group that owns the table, or have database superuser or administrative privileges.

10.3.10.1 Example - Deleting a Partition

The example that follows deletes a partition of the `sales` table. Use the following command to create the `sales` table:

```
CREATE TABLE sales
(
    dept_no      number,
    part_no      varchar2,
    country      varchar2(20),
    date         date,
    amount       number
)
PARTITION BY LIST(country)
(
    PARTITION europe VALUES ('FRANCE', 'ITALY'),
```

```
PARTITION asia VALUES('INDIA', 'PAKISTAN'),
PARTITION americas VALUES('US', 'CANADA')
);
```

Querying the ALL_TAB_PARTITIONS view displays the partition names:

```
acctg=# SELECT partition_name, high_value FROM ALL_TAB_PARTITIONS;
partition_name | high_value
-----+-----
EUROPE         | FOR VALUES IN ('FRANCE', 'ITALY')
ASIA          | FOR VALUES IN ('INDIA', 'PAKISTAN')
AMERICAS       | FOR VALUES IN ('US', 'CANADA')
(3 rows)
```

To delete the americas partition from the sales table, invoke the following command:

```
ALTER TABLE sales DROP PARTITION americas;
```

Querying the ALL_TAB_PARTITIONS view demonstrates that the partition has been successfully deleted:

```
acctg=# SELECT partition_name, high_value FROM ALL_TAB_PARTITIONS;
partition_name | high_value
-----+-----
EUROPE         | FOR VALUES IN ('FRANCE', 'ITALY')
ASIA          | FOR VALUES IN ('INDIA', 'PAKISTAN')
(2 rows)
```

10.3.11 ALTER TABLE... DROP SUBPARTITION

Use the `ALTER TABLE... DROP SUBPARTITION` command to drop a subpartition definition, and the data stored in that subpartition. The syntax is:

```
ALTER TABLE table_name DROP SUBPARTITION subpartition_name;
```

Parameters

table_name

The name (optionally schema-qualified) of the partitioned table.

subpartition_name

The name of the subpartition to be deleted.

Description

The `ALTER TABLE... DROP SUBPARTITION` command deletes a subpartition, and the data stored in that subpartition. To use the `DROP SUBPARTITION` clause, you must be the owner of the partitioning root, a member of a group that owns the table, or have superuser or administrative privileges.

10.3.11.1 Example - Deleting a Subpartition

The example that follows deletes a subpartition of the `sales` table. Use the following command to create the `sales` table:

```
CREATE TABLE sales
(
    dept_no      number,
    part_no      varchar2,
    country      varchar2(20),
    date         date,
    amount       number
)
PARTITION BY RANGE(date)
    SUBPARTITION BY LIST(country)
    (
        PARTITION first_half_2012 VALUES LESS THAN('01-JUL-2012')
        (
            SUBPARTITION europe VALUES ('ITALY', 'FRANCE'),
            SUBPARTITION americas VALUES ('CANADA', 'US'),
```

```

        SUBPARTITION asia VALUES ('PAKISTAN', 'INDIA')
    ) ,
    PARTITION second_half_2012 VALUES LESS THAN ('01-JAN-2013')
) ;

```

Querying the ALL_TAB_SUBPARTITIONS view displays the subpartition names:

```

acctg=# SELECT subpartition_name, high_value FROM ALL_TAB_SUBPARTITIONS;
subpartition_name | high_value
-----+-----
ASIA           | FOR VALUES IN ('PAKISTAN', 'INDIA')
AMERICAS       | FOR VALUES IN ('CANADA', 'US')
EUROPE         | FOR VALUES IN ('ITALY', 'FRANCE')
SYS0101        | DEFAULT
(4 rows)

```

To delete the americas subpartition from the sales table, invoke the following command:

```
ALTER TABLE sales DROP SUBPARTITION americas;
```

Querying the ALL_TAB_SUBPARTITIONS view demonstrates that the subpartition has been successfully deleted:

```

acctg=# SELECT subpartition_name, high_value FROM ALL_TAB_SUBPARTITIONS;
subpartition_name | high_value
-----+-----
ASIA           | FOR VALUES IN ('PAKISTAN', 'INDIA')
EUROPE         | FOR VALUES IN ('ITALY', 'FRANCE')
SYS0101        | DEFAULT
(3 rows)

```

10.3.12 TRUNCATE TABLE

Use the `TRUNCATE TABLE` command to remove the contents of a table, while preserving the table definition. When you truncate a table, any partitions or subpartitions of that table are also truncated. The syntax is:

```
TRUNCATE TABLE table_name
```

Description

The `TRUNCATE TABLE` command removes an entire table, and the data that resides in that table. When you delete a table, any partitions or subpartitions (of that table) are deleted as well.

To use the `TRUNCATE TABLE` command, you must be the owner of the partitioning root, a member of a group that owns the table, the schema owner, or a database superuser.

Parameters

table_name

The name (optionally schema-qualified) of the partitioned table.

10.3.12.1 Example - Emptying a Table

The example that follows removes the data from the `sales` table. Use the following command to create the `sales` table:

```
CREATE TABLE sales
(
    dept_no      number,
    part_no      varchar2,
    country      varchar2(20),
    date         date,
    amount       number
)
PARTITION BY LIST(country)
(
    PARTITION europe VALUES ('FRANCE', 'ITALY'),
    PARTITION asia VALUES ('INDIA', 'PAKISTAN'),
    PARTITION americas VALUES ('US', 'CANADA')
);
```

Populate the `sales` table with the command:

```
INSERT INTO sales VALUES
(10, '4519b', 'FRANCE', '17-Jan-2012', '45000'),
(20, '3788a', 'INDIA', '01-Mar-2012', '75000'),
(40, '9519b', 'US', '12-Apr-2012', '145000'),
(20, '3788a', 'PAKISTAN', '04-Jun-2012', '37500'),
(40, '4577b', 'US', '11-Nov-2012', '25000'),
(30, '7588b', 'CANADA', '14-Dec-2012', '50000'),
(30, '9519b', 'CANADA', '01-Feb-2012', '75000'),
(30, '4519b', 'CANADA', '08-Apr-2012', '120000'),
(40, '3788a', 'US', '12-May-2012', '4950'),
(10, '9519b', 'ITALY', '07-Jul-2012', '15000'),
(10, '9519a', 'FRANCE', '18-Aug-2012', '650000'),
(10, '9519b', 'FRANCE', '18-Aug-2012', '650000'),
(20, '3788b', 'INDIA', '21-Sept-2012', '5090'),
(40, '4788a', 'US', '23-Sept-2012', '4950'),
(40, '4788b', 'US', '09-Oct-2012', '15000'),
(20, '4519a', 'INDIA', '18-Oct-2012', '650000'),
(20, '4519b', 'INDIA', '2-Dec-2012', '5090');
```

Querying the `sales` table shows that the partitions are populated with data:

tableoid	dept_no	part_no	country	date	amount
sales_americas	40	9519b	US	12-APR-12 00:00:00	145000
sales_americas	40	4577b	US	11-NOV-12 00:00:00	25000
sales_americas	30	7588b	CANADA	14-DEC-12 00:00:00	50000
sales_americas	30	9519b	CANADA	01-FEB-12 00:00:00	75000
sales_americas	30	4519b	CANADA	08-APR-12 00:00:00	120000
sales_americas	40	3788a	US	12-MAY-12 00:00:00	4950
sales_americas	40	4788a	US	23-SEP-12 00:00:00	4950
sales_americas	40	4788b	US	09-OCT-12 00:00:00	15000
sales_europe	10	4519b	FRANCE	17-JAN-12 00:00:00	45000
sales_europe	10	9519b	ITALY	07-JUL-12 00:00:00	15000
sales_europe	10	9519a	FRANCE	18-AUG-12 00:00:00	650000
sales_europe	10	9519b	FRANCE	18-AUG-12 00:00:00	650000
sales_asia	20	3788a	INDIA	01-MAR-12 00:00:00	75000
sales_asia	20	3788a	PAKISTAN	04-JUN-12 00:00:00	37500
sales_asia	20	3788b	INDIA	21-SEP-12 00:00:00	5090
sales_asia	20	4519a	INDIA	18-OCT-12 00:00:00	650000
sales_asia	20	4519b	INDIA	02-DEC-12 00:00:00	5090

(17 rows)

To delete the contents of the `sales` table, invoke the following command:

```
TRUNCATE TABLE sales;
```

Now, querying the `sales` table shows that the data has been removed but the structure is intact:

tableoid	dept_no	part_no	country	date	amount
----------	---------	---------	---------	------	--------

```
-----+-----+-----+-----+-----+-----  
(0 rows)
```

For more information about the TRUNCATE TABLE command, please see the PostgreSQL documentation at:

<https://www.postgresql.org/docs/10/static/sql-truncate.html>

10.3.13 ALTER TABLE... TRUNCATE PARTITION

Use the `ALTER TABLE... TRUNCATE PARTITION` command to remove the data from the specified partition, leaving the partition structure intact. The syntax:

```
ALTER TABLE table_name TRUNCATE PARTITION partition_name
[ { DROP | REUSE } STORAGE ]
```

Description

Use the `ALTER TABLE... TRUNCATE PARTITION` command to remove the data from the specified partition, leaving the partition structure intact. When you truncate a partition, any subpartitions of that partition are also truncated.

`ALTER TABLE... TRUNCATE PARTITION` will not cause `ON DELETE` triggers that might exist for the table to fire, but it will fire `ON TRUNCATE` triggers. If an `ON TRUNCATE` trigger is defined for the partition, all `BEFORE TRUNCATE` triggers are fired before any truncation happens, and all `AFTER TRUNCATE` triggers are fired after the last truncation occurs.

You must have the `TRUNCATE` privilege on a table to invoke `ALTER TABLE... TRUNCATE PARTITION`.

Parameters

table_name

The name (optionally schema-qualified) of the partitioned table.

partition_name

The name of the partition to be deleted.

`DROP STORAGE` and `REUSE STORAGE` are included for compatibility only; the clauses are parsed and ignored.

10.3.13.1 Example - Emptying a Partition

The example that follows removes the data from a partition of the `sales` table. Use the following command to create the `sales` table:

```
CREATE TABLE sales
```

```

(
    dept_no      number,
    part_no      varchar2,
    country      varchar2(20),
    date         date,
    amount       number
)
PARTITION BY LIST(country)
(
    PARTITION europe VALUES('FRANCE', 'ITALY'),
    PARTITION asia VALUES('INDIA', 'PAKISTAN'),
    PARTITION americas VALUES('US', 'CANADA')
);

```

Populate the `sales` table with the command:

```

INSERT INTO sales VALUES
(10, '4519b', 'FRANCE', '17-Jan-2012', '45000'),
(20, '3788a', 'INDIA', '01-Mar-2012', '75000'),
(40, '9519b', 'US', '12-Apr-2012', '145000'),
(20, '3788a', 'PAKISTAN', '04-Jun-2012', '37500'),
(40, '4577b', 'US', '11-Nov-2012', '25000'),
(30, '7588b', 'CANADA', '14-Dec-2012', '50000'),
(30, '9519b', 'CANADA', '01-Feb-2012', '75000'),
(30, '4519b', 'CANADA', '08-Apr-2012', '120000'),
(40, '3788a', 'US', '12-May-2012', '4950'),
(10, '9519b', 'ITALY', '07-Jul-2012', '15000'),
(10, '9519a', 'FRANCE', '18-Aug-2012', '650000'),
(10, '9519b', 'FRANCE', '18-Aug-2012', '650000'),
(20, '3788b', 'INDIA', '21-Sept-2012', '5090'),
(40, '4788a', 'US', '23-Sept-2012', '4950'),
(40, '4788b', 'US', '09-Oct-2012', '15000'),
(20, '4519a', 'INDIA', '18-Oct-2012', '650000'),
(20, '4519b', 'INDIA', '2-Dec-2012', '5090');

```

Querying the `sales` table shows that the partitions are populated with data:

tableoid::regclass	*	FROM	sales						
tableoid	dept_no	part_no	country	date	amount				
sales_americas	40	9519b	US	12-APR-12 00:00:00	145000				
sales_americas	40	4577b	US	11-NOV-12 00:00:00	25000				
sales_americas	30	7588b	CANADA	14-DEC-12 00:00:00	50000				
sales_americas	30	9519b	CANADA	01-FEB-12 00:00:00	75000				
sales_americas	30	4519b	CANADA	08-APR-12 00:00:00	120000				
sales_americas	40	3788a	US	12-MAY-12 00:00:00	4950				
sales_americas	40	4788a	US	23-SEP-12 00:00:00	4950				
sales_americas	40	4788b	US	09-OCT-12 00:00:00	15000				
sales_europe	10	4519b	FRANCE	17-JAN-12 00:00:00	45000				
sales_europe	10	9519b	ITALY	07-JUL-12 00:00:00	15000				
sales_europe	10	9519a	FRANCE	18-AUG-12 00:00:00	650000				
sales_europe	10	9519b	FRANCE	18-AUG-12 00:00:00	650000				
sales_asia	20	3788a	INDIA	01-MAR-12 00:00:00	75000				
sales_asia	20	3788a	PAKISTAN	04-JUN-12 00:00:00	37500				

```

sales_asia | 20 | 3788b | INDIA | 21-SEP-12 00:00:00 | 5090
sales_asia | 20 | 4519a | INDIA | 18-OCT-12 00:00:00 | 650000
sales_asia | 20 | 4519b | INDIA | 02-DEC-12 00:00:00 | 5090
(17 rows)

```

To delete the contents of the `americas` partition, invoke the following command:

```
ALTER TABLE sales TRUNCATE PARTITION americas;
```

Now, querying the `sales` table shows that the content of the `americas` partition has been removed:

```

acctg=# SELECT tableoid::regclass, * FROM sales;
   tableoid | dept_no | part_no | country |          date | amount
-----+-----+-----+-----+-----+-----+
sales_europe |    10 | 4519b | FRANCE | 17-JAN-12 00:00:00 | 45000
sales_europe |    10 | 9519b | ITALY | 07-JUL-12 00:00:00 | 15000
sales_europe |    10 | 9519a | FRANCE | 18-AUG-12 00:00:00 | 650000
sales_europe |    10 | 9519b | FRANCE | 18-AUG-12 00:00:00 | 650000
sales_asia |    20 | 3788a | INDIA | 01-MAR-12 00:00:00 | 75000
sales_asia |    20 | 3788a | PAKISTAN | 04-JUN-12 00:00:00 | 37500
sales_asia |    20 | 3788b | INDIA | 21-SEP-12 00:00:00 | 5090
sales_asia |    20 | 4519a | INDIA | 18-OCT-12 00:00:00 | 650000
sales_asia |    20 | 4519b | INDIA | 02-DEC-12 00:00:00 | 5090
(9 rows)

```

While the rows have been removed, the structure of the `americas` partition is still intact:

```

acctg=# SELECT partition_name, high_value FROM ALL_TAB_PARTITIONS;
partition_name | high_value
-----+-----
EUROPE | FOR VALUES IN ('FRANCE', 'ITALY')
ASIA | FOR VALUES IN ('INDIA', 'PAKISTAN')
AMERICAS | FOR VALUES IN ('US', 'CANADA')
(3 rows)

```

10.3.14 ALTER TABLE... TRUNCATE SUBPARTITION

Use the `ALTER TABLE... TRUNCATE SUBPARTITION` command to remove all of the data from the specified subpartition, leaving the subpartition structure intact. The syntax is:

```
ALTER TABLE table_name
    TRUNCATE SUBPARTITION subpartition_name
    [ { DROP | REUSE } STORAGE ]
```

Description

The `ALTER TABLE... TRUNCATE SUBPARTITION` command removes all data from a specified subpartition, leaving the subpartition structure intact.

`ALTER TABLE... TRUNCATE SUBPARTITION` will not cause `ON DELETE` triggers that might exist for the table to fire, but it will fire `ON TRUNCATE` triggers. If an `ON TRUNCATE` trigger is defined for the subpartition, all `BEFORE TRUNCATE` triggers are fired before any truncation happens, and all `AFTER TRUNCATE` triggers are fired after the last truncation occurs.

You must have the `TRUNCATE` privilege on a table to invoke `ALTER TABLE... TRUNCATE SUBPARTITION`.

Parameters

table_name

The name (optionally schema-qualified) of the partitioned table.

subpartition_name

The name of the subpartition to be truncated.

The `DROP STORAGE` and `REUSE STORAGE` clauses are included for compatibility only; the clauses are parsed and ignored.

10.3.14.1 Example - Emptying a Subpartition

The example that follows removes the data from a subpartition of the `sales` table. Use the following command to create the `sales` table:

```
CREATE TABLE sales
(
```

```

dept_no      number,
part_no      varchar2,
country      varchar2(20),
date         date,
amount       number
)
PARTITION BY RANGE(date) SUBPARTITION BY LIST (country)
(
  PARTITION "2011" VALUES LESS THAN ('01-JAN-2012')
  (
    SUBPARTITION europe_2011 VALUES ('ITALY', 'FRANCE'),
    SUBPARTITION asia_2011 VALUES ('PAKISTAN', 'INDIA'),
    SUBPARTITION americas_2011 VALUES ('US', 'CANADA')
  ),
  PARTITION "2012" VALUES LESS THAN ('01-JAN-2013')
  (
    SUBPARTITION europe_2012 VALUES ('ITALY', 'FRANCE'),
    SUBPARTITION asia_2012 VALUES ('PAKISTAN', 'INDIA'),
    SUBPARTITION americas_2012 VALUES ('US', 'CANADA')
  ),
  PARTITION "2013" VALUES LESS THAN ('01-JAN-2015')
  (
    SUBPARTITION europe_2013 VALUES ('ITALY', 'FRANCE'),
    SUBPARTITION asia_2013 VALUES ('PAKISTAN', 'INDIA'),
    SUBPARTITION americas_2013 VALUES ('US', 'CANADA')
  )
);

```

Populate the `sales` table with the command:

```

INSERT INTO sales VALUES
(10, '4519b', 'FRANCE', '17-Jan-2011', '45000'),
(20, '3788a', 'INDIA', '01-Mar-2012', '75000'),
(40, '9519b', 'US', '12-Apr-2012', '145000'),
(20, '3788a', 'PAKISTAN', '04-Jun-2012', '37500'),
(40, '4577b', 'US', '11-Nov-2012', '25000'),
(30, '7588b', 'CANADA', '14-Dec-2011', '50000'),
(30, '4519b', 'CANADA', '08-Apr-2012', '120000'),
(40, '3788a', 'US', '12-May-2011', '4950'),
(20, '3788a', 'US', '04-Apr-2012', '37500'),
(40, '4577b', 'INDIA', '11-Jun-2011', '25000'),
(10, '9519b', 'ITALY', '07-Jul-2012', '15000'),
(20, '4519b', 'INDIA', '2-Dec-2012', '5090');

```

Querying the `sales` table shows that the rows have been distributed amongst the subpartitions:

tableoid::regclass	dept_no	part_no	country	date	amount
sales_americas_2011	30	7588b	CANADA	14-DEC-11 00:00:00	50000

sales_americas_2011	40	3788a	US	12-MAY-11 00:00:00	4950
sales_europe_2011	10	4519b	FRANCE	17-JAN-11 00:00:00	45000
sales_asia_2011	40	4577b	INDIA	11-JUN-11 00:00:00	25000
sales_americas_2012	40	9519b	US	12-APR-12 00:00:00	145000
sales_americas_2012	40	4577b	US	11-NOV-12 00:00:00	25000
sales_americas_2012	30	4519b	CANADA	08-APR-12 00:00:00	120000
sales_americas_2012	20	3788a	US	04-APR-12 00:00:00	37500
sales_europe_2012	10	9519b	ITALY	07-JUL-12 00:00:00	15000
sales_asia_2012	20	3788a	INDIA	01-MAR-12 00:00:00	75000
sales_asia_2012	20	3788a	PAKISTAN	04-JUN-12 00:00:00	37500
sales_asia_2012	20	4519b	INDIA	02-DEC-12 00:00:00	5090

To delete the contents of the `2012_americas` partition, invoke the following command:

```
ALTER TABLE sales TRUNCATE SUBPARTITION "americas_2012";
```

Now, querying the `sales` table shows that the content of the `americas_2012` partition has been removed:

acctg=# SELECT tableoid::regclass, * FROM sales;					
tableoid	dept_no	part_no	country	date	amount
sales_americas_2011	30	7588b	CANADA	14-DEC-11 00:00:00	50000
sales_americas_2011	40	3788a	US	12-MAY-11 00:00:00	4950
sales_europe_2011	10	4519b	FRANCE	17-JAN-11 00:00:00	45000
sales_asia_2011	40	4577b	INDIA	11-JUN-11 00:00:00	25000
sales_europe_2012	10	9519b	ITALY	07-JUL-12 00:00:00	15000
sales_asia_2012	20	3788a	INDIA	01-MAR-12 00:00:00	75000
sales_asia_2012	20	3788a	PAKISTAN	04-JUN-12 00:00:00	37500
sales_asia_2012	20	4519b	INDIA	02-DEC-12 00:00:00	5090

While the rows have been removed, the structure of the `2012_americas` partition is still intact:

acctg=# SELECT subpartition_name, high_value FROM ALL_TAB_SUBPARTITIONS;	
subpartition_name	high_value
AMERICAS_2011	FOR VALUES IN ('US', 'CANADA')
ASIA_2011	FOR VALUES IN ('PAKISTAN', 'INDIA')
EUROPE_2011	FOR VALUES IN ('ITALY', 'FRANCE')
AMERICAS_2012	FOR VALUES IN ('US', 'CANADA')
ASIA_2012	FOR VALUES IN ('PAKISTAN', 'INDIA')
EUROPE_2012	FOR VALUES IN ('ITALY', 'FRANCE')
AMERICAS_2013	FOR VALUES IN ('US', 'CANADA')
ASIA_2013	FOR VALUES IN ('PAKISTAN', 'INDIA')
EUROPE_2013	FOR VALUES IN ('ITALY', 'FRANCE')

10.4 Handling Stray Values in a LIST or RANGE Partitioned Table

A `DEFAULT` or `MAXVALUE` partition or subpartition will capture any rows that do not meet the other partitioning rules defined for a table.

Defining a `DEFAULT` Partition

A `DEFAULT` partition will capture any rows that do not fit into any other partition in a `LIST` partitioned (or subpartitioned) table. If you do not include a `DEFAULT` rule, any row that does not match one of the values in the partitioning constraints will result in an error. Each `LIST` partition or subpartition may have its own `DEFAULT` rule.

The syntax of a `DEFAULT` rule is:

```
PARTITION [partition_name] VALUES (DEFAULT)
```

Where `partition_name` specifies the name of the partition or subpartition that will store any rows that do not match the rules specified for other partitions.

The last example created a list partitioned table in which the server decided which partition to store the data based upon the value of the `country` column. If you attempt to add a row in which the value of the `country` column contains a value not listed in the rules, Advanced Server reports an error:

```
acctg=# INSERT INTO sales VALUES
acctg-# (40, '3000x', 'IRELAND', '01-Mar-2012', '45000');
ERROR: no partition of relation "sales_2012" found for row
DETAIL: Partition key of the failing row contains (country) = (IRELAND).
```

The following example creates the same table, but adds a `DEFAULT` partition. The server will store any rows that do not match a value specified in the partitioning rules for `europe`, `asia`, or `americas` partitions in the `others` partition:

```
CREATE TABLE sales
(
    dept_no      number,
    part_no      varchar2,
    country      varchar2(20),
    date         date,
    amount        number
)
PARTITION BY LIST(country)
(
    PARTITION europe VALUES ('FRANCE', 'ITALY'),
    PARTITION asia VALUES ('INDIA', 'PAKISTAN'),
    PARTITION americas VALUES ('US', 'CANADA'),
    PARTITION others VALUES (DEFAULT)
);
```

To test the `DEFAULT` partition, add row with a value in the `country` column that does not match one of the countries specified in the partitioning constraints:

```
INSERT INTO sales VALUES
(40, '3000x', 'IRELAND', '01-Mar-2012', '45000');
```

Querying the contents of the `sales` table confirms that the previously rejected row is now stored in the `sales_others` partition:

acctg#	SELECT tableoid::regclass, * FROM sales;				
tableoid	dept_no	part_no	country	date	amount
sales_americas	40	9519b	US	12-APR-12 00:00:00	145000
sales_americas	40	4577b	US	11-NOV-12 00:00:00	25000
sales_americas	30	7588b	CANADA	14-DEC-12 00:00:00	50000
sales_americas	30	9519b	CANADA	01-FEB-12 00:00:00	75000
sales_americas	30	4519b	CANADA	08-APR-12 00:00:00	120000
sales_americas	40	3788a	US	12-MAY-12 00:00:00	4950
sales_americas	40	4788a	US	23-SEP-12 00:00:00	4950
sales_americas	40	4788b	US	09-OCT-12 00:00:00	15000
sales_europe	10	4519b	FRANCE	17-JAN-12 00:00:00	45000
sales_europe	10	9519b	ITALY	07-JUL-12 00:00:00	15000
sales_europe	10	9519a	FRANCE	18-AUG-12 00:00:00	650000
sales_europe	10	9519b	FRANCE	18-AUG-12 00:00:00	650000
sales_asia	20	3788a	INDIA	01-MAR-12 00:00:00	75000
sales_asia	20	3788a	PAKISTAN	04-JUN-12 00:00:00	37500
sales_asia	20	3788b	INDIA	21-SEP-12 00:00:00	5090
sales_asia	20	4519a	INDIA	18-OCT-12 00:00:00	650000
sales_asia	20	4519b	INDIA	02-DEC-12 00:00:00	5090
sales_others	40	3000x	IRELAND	01-MAR-12 00:00:00	45000

(18 rows)

Please note that Advanced Server does not have a way to re-assign the contents of a `DEFAULT` partition or subpartition:

- You cannot use the `ALTER TABLE...ADD PARTITION` command to add a partition to a table with a `DEFAULT` rule, but you can use the `ALTER TABLE...SPLIT PARTITION` command to split an existing partition. An example is shown following this bullet pointlist.
- You cannot use the `ALTER TABLE...ADD SUBPARTITION` command to add a subpartition to a table with a `DEFAULT` rule, but you can use the `ALTER TABLE...SPLIT SUBPARTITION` command to split an existing subpartition.

Splitting a `DEFAULT` Partition

The following example splits a `DEFAULT` partition, redistributing the partition's content between two new partitions. The table was created with the `CREATE TABLE sales` command shown at the beginning of this section.

The following inserts rows into the table including rows into the `DEFAULT` partition:

```
INSERT INTO sales VALUES
(10, '4519b', 'FRANCE', '17-Jan-2012', '45000'),
(10, '9519b', 'ITALY', '07-Jul-2012', '15000'),
(20, '3788a', 'INDIA', '01-Mar-2012', '75000'),
(20, '3788a', 'PAKISTAN', '04-Jun-2012', '37500'),
(30, '9519b', 'US', '12-Apr-2012', '145000'),
(30, '7588b', 'CANADA', '14-Dec-2012', '50000'),
(40, '4519b', 'SOUTH AFRICA', '08-Apr-2012', '120000'),
(40, '4519b', 'KENYA', '08-Apr-2012', '120000'),
(50, '3788a', 'CHINA', '12-May-2012', '4950');
```

The partitions include the `DEFAULT others` partition:

```
edb=# SELECT partition_name, high_value FROM all_tab_partitions;
partition_name | high_value
-----+-----
EUROPE        | FOR VALUES IN ('FRANCE', 'ITALY')
ASIA          | FOR VALUES IN ('INDIA', 'PAKISTAN')
AMERICAS      | FOR VALUES IN ('US', 'CANADA')
OTHERS         | DEFAULT
(4 rows)
```

The following shows the rows distributed amongst the partitions:

```
edb=# SELECT tableoid::regclass, * FROM sales;
tableoid | dept no | part no | country | date           | amount
-----+-----+-----+-----+-----+-----+
sales_americas | 30 | 9519b | US       | 12-APR-12 00:00:00 | 145000
sales_americas | 30 | 7588b | CANADA   | 14-DEC-12 00:00:00 | 50000
sales_europe    | 10 | 4519b | FRANCE   | 17-JAN-12 00:00:00 | 45000
sales_europe    | 10 | 9519b | ITALY    | 07-JUL-12 00:00:00 | 15000
sales_asia      | 20 | 3788a | INDIA    | 01-MAR-12 00:00:00 | 75000
sales_asia      | 20 | 3788a | PAKISTAN | 04-JUN-12 00:00:00 | 37500
sales_others    | 40 | 4519b | SOUTH AFRICA | 08-APR-12 00:00:00 | 120000
sales_others    | 40 | 4519b | KENYA    | 08-APR-12 00:00:00 | 120000
sales_others    | 50 | 3788a | CHINA    | 12-MAY-12 00:00:00 | 4950
(9 rows)
```

The following command splits the `DEFAULT others` partition into two partitions named `africa` and `others`:

```
ALTER TABLE sales SPLIT PARTITION others VALUES
('SOUTH AFRICA', 'KENYA')
INTO (PARTITION africa, PARTITION others);
```

The partitions now include the `africa` partition along with the `DEFAULT others` partition:

```
edb=# SELECT partition_name, high_value FROM all_tab_partitions;
partition_name | high_value
-----+-----
EUROPE        | FOR VALUES IN ('FRANCE', 'ITALY')
ASIA          | FOR VALUES IN ('INDIA', 'PAKISTAN')
AMERICAS      | FOR VALUES IN ('US', 'CANADA')
AFRICA         | FOR VALUES IN ('SOUTH AFRICA', 'KENYA')
OTHERS         | DEFAULT
```

(5 rows)

The following shows that the rows have been redistributed across the new partitions:

```
edb=# SELECT tableoid::regclass, * FROM sales;
   tableoid | dept_no | part_no | country      |          date    | amount
-----+-----+-----+-----+-----+-----+-----+
sales_americas | 30 | 9519b | US           | 12-APR-12 00:00:00 | 145000
sales_americas | 30 | 7588b | CANADA       | 14-DEC-12 00:00:00 | 50000
sales_europe    | 10 | 4519b | FRANCE       | 17-JAN-12 00:00:00 | 45000
sales_europe    | 10 | 9519b | ITALY         | 07-JUL-12 00:00:00 | 15000
sales_asia      | 20 | 3788a | INDIA        | 01-MAR-12 00:00:00 | 75000
sales_asia      | 20 | 3788a | PAKISTAN     | 04-JUN-12 00:00:00 | 37500
sales_africa    | 40 | 4519b | SOUTH AFRICA | 08-APR-12 00:00:00 | 120000
sales_africa    | 40 | 4519b | KENYA         | 08-APR-12 00:00:00 | 120000
sales_others_1  | 50 | 3788a | CHINA        | 12-MAY-12 00:00:00 | 4950
(9 rows)
```

Defining a MAXVALUE Partition

A MAXVALUE partition (or subpartition) will capture any rows that do not fit into any other partition in a range-partitioned (or subpartitioned) table. If you do not include a MAXVALUE rule, any row that exceeds the maximum limit specified by the partitioning rules will result in an error. Each partition or subpartition may have its own MAXVALUE partition.

The syntax of a MAXVALUE rule is:

```
PARTITION [partition_name] VALUES LESS THAN (MAXVALUE)
```

Where *partition_name* specifies the name of the partition that will store any rows that do not match the rules specified for other partitions.

The last example created a range-partitioned table in which the data was partitioned based upon the value of the `date` column. If you attempt to add a row with a `date` that exceeds a date listed in the partitioning constraints, Advanced Server reports an error:

```
acctg=# INSERT INTO sales VALUES
acctg-#   (40, '3000x', 'IRELAND', '01-Mar-2013', '45000');
ERROR: no partition of relation "sales" found for row
DETAIL: Partition key of the failing row contains (date) = (01-MAR-13 00:00:00).
```

The following CREATE TABLE command creates the same table, but with a MAXVALUE partition. Instead of throwing an error, the server will store any rows that do not match the previous partitioning constraints in the `others` partition:

```
CREATE TABLE sales
(
  dept_no      number,
  part_no      varchar2,
  country      varchar2(20),
```

```

        date      date,
        amount    number
)
PARTITION BY RANGE (date)
(
    PARTITION q1_2012 VALUES LESS THAN ('2012-Apr-01'),
    PARTITION q2_2012 VALUES LESS THAN ('2012-Jul-01'),
    PARTITION q3_2012 VALUES LESS THAN ('2012-Oct-01'),
    PARTITION q4_2012 VALUES LESS THAN ('2013-Jan-01'),
    PARTITION others VALUES LESS THAN (MAXVALUE)
);

```

To test the MAXVALUE partition, add a row with a value in the `date` column that exceeds the last date value listed in a partitioning rule. The server will store the row in the `others` partition:

```

INSERT INTO sales VALUES
(40, '3000x', 'IRELAND', '01-Mar-2013', '45000');

```

Querying the contents of the `sales` table confirms that the previously rejected row is now stored in the `sales_others` partition :

tableoid	dept_no	part_no	country	date	amount
sales_q1_2012	10	4519b	FRANCE	17-JAN-12 00:00:00	45000
sales_q1_2012	20	3788a	INDIA	01-MAR-12 00:00:00	75000
sales_q1_2012	30	9519b	CANADA	01-FEB-12 00:00:00	75000
sales_q2_2012	40	9519b	US	12-APR-12 00:00:00	145000
sales_q2_2012	20	3788a	PAKISTAN	04-JUN-12 00:00:00	37500
sales_q2_2012	30	4519b	CANADA	08-APR-12 00:00:00	120000
sales_q2_2012	40	3788a	US	12-MAY-12 00:00:00	4950
sales_q3_2012	10	9519b	ITALY	07-JUL-12 00:00:00	15000
sales_q3_2012	10	9519a	FRANCE	18-AUG-12 00:00:00	650000
sales_q3_2012	10	9519b	FRANCE	18-AUG-12 00:00:00	650000
sales_q3_2012	20	3788b	INDIA	21-SEP-12 00:00:00	5090
sales_q3_2012	40	4788a	US	23-SEP-12 00:00:00	4950
sales_q4_2012	40	4577b	US	11-NOV-12 00:00:00	25000
sales_q4_2012	30	7588b	CANADA	14-DEC-12 00:00:00	50000
sales_q4_2012	40	4788b	US	09-OCT-12 00:00:00	15000
sales_q4_2012	20	4519a	INDIA	18-OCT-12 00:00:00	650000
sales_q4_2012	20	4519b	INDIA	02-DEC-12 00:00:00	5090
sales_others	40	3000x	IRELAND	01-MAR-13 00:00:00	45000

Please note that Advanced Server does not have a way to re-assign the contents of a MAXVALUE partition or subpartition:

- You cannot use the `ALTER TABLE...ADD PARTITION` statement to add a partition to a table with a MAXVALUE rule, but you can use the `ALTER TABLE...SPLIT PARTITION` statement to split an existing partition.

- You cannot use the `ALTER TABLE...ADD SUBPARTITION` statement to add a subpartition to a table with a `MAXVALUE` rule , but you can split an existing subpartition with the `ALTER TABLE...SPLIT SUBPARTITION` statement.

10.5 Specifying Multiple Partitioning Keys in a RANGE Partitioned Table

You can often improve performance by specifying multiple key columns for a RANGE partitioned table. If you often select rows using comparison operators (based on a greater-than or less-than value) on a small set of columns, consider using those columns in RANGE partitioning rules.

Specifying Multiple Keys in a Range-Partitioned Table

Range-partitioned table definitions may include multiple columns in the partitioning key. To specify multiple partitioning keys for a range-partitioned table, include the column names in a comma-separated list after the PARTITION BY RANGE clause:

```
CREATE TABLE sales
(
    dept_no      number,
    part_no      varchar2,
    country      varchar2(20),
    sale_year    number,
    sale_month   number,
    sale_day     number,
    amount       number
)
PARTITION BY RANGE(sale_year, sale_month)
(
    PARTITION q1_2012
        VALUES LESS THAN(2012, 4),
    PARTITION q2_2012
        VALUES LESS THAN(2012, 7),
    PARTITION q3_2012
        VALUES LESS THAN(2012, 10),
    PARTITION q4_2012
        VALUES LESS THAN(2013, 1)
);
```

If a table is created with multiple partitioning keys, you must specify multiple key values when querying the table to take full advantage of partition pruning:

```
acctg=# EXPLAIN SELECT * FROM sales WHERE sale_year = 2012 AND sale_month = 8;
          QUERY PLAN
-----
 Append  (cost=0.00..14.35 rows=1 width=250)
   -> Seq Scan on sales_q3_2012  (cost=0.00..14.35 rows=1 width=250)
       Filter: ((sale_year = '2012'::numeric) AND (sale_month = '8'::numeric))
(3 rows)
```

Since all rows with a value of 8 in the `sale_month` column and a value of 2012 in the `sale_year` column will be stored in the `q3_2012` partition, Advanced Server searches only that partition.

10.6 Retrieving Information about a Partitioned Table

Advanced Server provides five system catalog views that you can use to view information about the structure of partitioned tables.

Querying the Partitioning Views

You can query the following views to retrieve information about partitioned and subpartitioned tables:

- ALL_PART_TABLES
- ALL_TAB_PARTITIONS
- ALL_TAB_SUBPARTITIONS
- ALL_PART_KEY_COLUMNS
- ALL_SUBPART_KEY_COLUMNS

The structure of each view is explained in Section [10.6.1, Table Partitioning Views](#). If you are using the EDB-PSQL client, you can also discover the structure of a view by entering:

```
\d view_name
```

Where *view_name* specifies the name of the table partitioning view.

Querying a view can provide information about the structure of a partitioned or subpartitioned table. For example, the following code snippet displays the names of a subpartitioned table:

```
acctg=# SELECT subpartition_name, partition_name FROM ALL_TAB_SUBPARTITIONS;
subpartition_name | partition_name
-----+-----
EUROPE_2011      | EUROPE
EUROPE_2012      | EUROPE
ASIA_2011        | ASIA
ASIA_2012        | ASIA
AMERICAS_2011    | AMERICAS
AMERICAS_2012    | AMERICAS
(6 rows)
```

10.6.1 Table Partitioning Views - Reference

Query the following catalog views, compatible with Oracle databases, to review detailed information about your partitioned tables.

10.6.1.1 ALL_PART_TABLES

The following table lists the information available in the ALL_PART_TABLES view:

Column	Type	Description
owner	name	The owner of the table.
schema_name	name	The schema in which the table resides.
table_name	name	The name of the table.
partitioning_type	text	RANGE, LIST or HASH
subpartitioning_type	text	RANGE, LIST, HASH, or NONE
partition_count	bigint	The number of partitions.
def_subpartition_count	integer	The default subpartition count - this will always be 0.
partitioning_key_count	integer	The number of columns listed in the partition by clause.
subpartitioning_key_count	integer	The number of columns in the subpartition by clause.
status	character varying(8)	This column will always be VALID.
def_tablespace_name	character varying(30)	This column will always be NULL.
def_pct_free	numeric	This column will always be NULL.
def_pct_used	numeric	This column will always be NULL.
def_ini_trans	numeric	This column will always be NULL.
def_max_trans	numeric	This column will always be NULL.
def_initial_extent	character varying(40)	This column will always be NULL.
def_next_extent	character varying(40)	This column will always be NULL.
def_min_extents	character varying(40)	This column will always be NULL.
def_max_extents	character varying(40)	This column will always be NULL.
def_pct_increase	character varying(40)	This column will always be NULL.
def_freelists	numeric	This column will always be NULL.
def_freelist_groups	numeric	This column will always be NULL.
def_logging	character varying(7)	This column will always be YES
def_compression	character varying(8)	This column will always be NONE
def_buffer_pool	character varying(7)	This column will always be DEFAULT
ref_ptn_constraint_name	character varying(30)	This column will always be NULL
interval	character varying(1000)	This column will always be NULL

10.6.1.2 ALL_TAB_PARTITIONS

The following table lists the information available in the ALL_TAB_PARTITIONS view:

Column	Type	Description
table_owner	name	The owner of the table.
schema_name	name	The schema in which the table resides.
table_name	name	The name of the table.
composite	text	YES if the table is subpartitioned; NO if it is not subpartitioned.
partition_name	name	The name of the partition.
subpartition_count	bigint	The number of subpartitions for this partition.
high_value	text	The partition limit for RANGE partitions, or the partition value for LIST partitions.
high_value_length	integer	The length of high_value.
partition_position	integer	This column will always be NULL.
tablespace_name	name	The tablespace in which this partition resides.
pct_free	numeric	This column will always be 0.
pct_used	numeric	This column will always be 0.
ini_trans	numeric	This column will always be 0.
max_trans	numeric	This column will always be 0.
initial_extent	numeric	This column will always be NULL.
next_extent	numeric	This column will always be NULL.
min_extent	numeric	This column will always be 0.
max_extent	numeric	This column will always be 0.
pct_increase	numeric	This column will always be 0.
freelists	numeric	This column will always be NULL
freelist_groups	numeric	This column will always be NULL
logging	character varying(7)	This column will always be YES.
compression	character varying(8)	This column will always be NONE.
num_rows	numeric	The approx. number of rows in this partition.
blocks	integer	The approx. number of blocks in this partition.
empty_blocks	numeric	This column will always be NULL
avg_space	numeric	This column will always be NULL
chain_cnt	numeric	This column will always be NULL
avg_row_len	numeric	This column will always be NULL
sample_size	numeric	This column will always be NULL
last_analyzed	timestamp without time zone	This column will always be NULL
buffer_pool	character varying(7)	This column will always be NULL
global_stats	character varying(3)	This column will always be YES.
user_stats	character varying(3)	This column will always be NO.
backing_table	regclass	OID of the backing table for this partition.

10.6.1.3 ALL_TAB_SUBPARTITIONS

The following table lists the information available in the ALL_TAB_SUBPARTITIONS view:

Column	Type	Description
table_owner	name	The name of the owner of the table.
schema_name	name	The name of the schema in which the table resides.
table_name	name	The name of the table.
partition_name	name	The name of the partition.
subpartition_name	name	The name of the subpartition.
high_value	text	The subpartition limit for RANGE subpartitions, or the subpartition value for LIST subpartitions.
high_value_length	integer	The length of high_value.
subpartition_position	integer	This column will always be NULL.
tablespace_name	name	The tablespace in which this subpartition resides.
pct_free	numeric	This column will always be 0.
pct_used	numeric	This column will always be 0.
ini_trans	numeric	This column will always be 0.
max_trans	numeric	This column will always be 0.
initial_extent	numeric	This column will always be NULL.
next_extent	numeric	This column will always be NULL.
min_extent	numeric	This column will always be 0.
max_extent	numeric	This column will always be 0.
pct_increase	numeric	This column will always be 0.
freelists	numeric	This column will always be NULL.
freelist_groups	numeric	This column will always be NULL.
logging	character varying(7)	This column will always be YES.
compression	character varying(8)	This column will always be NONE.
num_rows	numeric	The approx. number of rows in this subpartition.
blocks	integer	The approx. number of blocks in this subpartition.
empty_blocks	numeric	This column will always be NULL.
avg_space	numeric	This column will always be NULL.
chain_cnt	numeric	This column will always be NULL.
avg_row_len	numeric	This column will always be NULL.
sample_size	numeric	This column will always be NULL.
last_analyzed	timestamp without time zone	This column will always be NULL.
buffer_pool	character varying(7)	This column will always be NULL.
global_stats	character varying(3)	This column will always be YES.
user_stats	character varying(3)	This column will always be NO.
backing_table	regclass	OID of the backing table for this subpartition.

10.6.1.4 ALL_PART_KEY_COLUMNS

The following table lists the information available in the ALL_PART_KEY_COLUMNS view:

Column	Type	Description
owner	name	The name of the table owner.
schema_name	name	The name of the schema on which the table resides.
name	name	The name of the table.
object_type	character(5)	This column will always be TABLE.
column_name	name	The name of the partitioning key column.
column_position	integer	The position of this column within the partitioning key (the first column has a column position of 1, the second column has a column position of 2...)

10.6.1.5 ALL_SUBPART_KEY_COLUMNS

The following table lists the information available in the ALL_SUBPART_KEY_COLUMNS view:

Column	Type	Description
owner	name	The name of the table owner.
schema_name	name	The name of the schema on which the table resides.
name	name	The name of the table.
object_type	character(5)	This column will always be TABLE.
column_name	name	The name of the partitioning key column.
column_position	integer	The position of this column within the subpartitioning key (the first column has a column position of 1, the second column has a column position of 2...)

11 ECPGPlus

EnterpriseDB has enhanced ECPG (the PostgreSQL pre-compiler) to create ECPGPlus. ECPGPlus allows you to include embedded SQL commands in C applications; when you use ECPGPlus to compile an application that contains embedded SQL commands, the SQL code is syntax-checked and translated into C.

ECPGPlus supports Pro*C compatible syntax in C programs when connected to an Advanced Server database. ECPGPlus supports:

- Oracle Dynamic SQL – Method 4 (ODS-M4).
- Pro*C compatible anonymous blocks.
- A `CALL` statement compatible with Oracle databases.

As part of ECPGPlus' Pro*C compatibility, you do not need to include the `BEGIN DECLARE SECTION` and `END DECLARE SECTION` directives.

For more information about using ECPGPlus, please see the EDB Postgres Advanced Server ECPG Connector Guide available from the EnterpriseDB website at:

<https://www.enterprisedb.com/resources/product-documentation>

12 dblink_ora

`dblink_ora` provides an OCI-based database link that allows you to `SELECT`, `INSERT`, `UPDATE` or `DELETE` data stored on an Oracle system from within Advanced Server.

Connecting to an Oracle Database

To enable Oracle connectivity, download Oracle's freely available OCI drivers from their website, presently at:

<http://www.oracle.com/technetwork/database/features/instant-client/index-100365.html>

For Linux, if the Oracle instant client that you've downloaded does not include the `libclntsh.so` library, you must create a symbolic link named `libclntsh.so` that points to the downloaded version. Navigate to the instant client directory and execute the following command:

```
ln -s libclntsh.so.version libclntsh.so
```

Where `version` is the version number of the `libclntsh.so` library. For example:

```
ln -s libclntsh.so.12.1 libclntsh.so
```

Before creating a link to an Oracle server, you must tell Advanced Server where to find the OCI driver.

Set the `LD_LIBRARY_PATH` environment variable on Linux (or `PATH` on Windows) to the `lib` directory of the Oracle client installation directory.

For Windows only, you can instead set the value of the `oracle_home` configuration parameter in the `postgresql.conf` file. The value specified in the `oracle_home` configuration parameter will override the Windows `PATH` environment variable.

The `LD_LIBRARY_PATH` environment variable on Linux (`PATH` environment variable or `oracle_home` configuration parameter on Windows) must be set properly each time you start Advanced Server.

When using a Linux service script to start Advanced Server, be sure `LD_LIBRARY_PATH` has been set within the service script so it is in effect when the script invokes the `pg_ctl` utility to start Advanced Server.

For Windows only: To set the `oracle_home` configuration parameter in the `postgresql.conf` file, edit the file, adding the following line:

```
oracle_home = 'lib_directory'
```

Substitute the name of the Windows directory that contains `oci.dll` for `lib_directory`.

After setting the `oracle_home` configuration parameter, you must restart the server for the changes to take effect. Restart the server from the Windows Services console.

12.1 dblink_ora Functions and Procedures

`dblink_ora` supports the following functions and procedures.

12.1.1 dblink_ora_connect()

The `dblink_ora_connect()` function establishes a connection to an Oracle database with user-specified connection information. The function comes in two forms; the signature of the first form is:

```
dblink_ora_connect(conn_name, server_name, service_name,
user_name, password, port, asDBA)
```

Where:

`conn_name` specifies the name of the link.

`server_name` specifies the name of the host.

`service_name` specifies the name of the service.

`user_name` specifies the name used to connect to the server.

`password` specifies the password associated with the user name.

`port` specifies the port number.

`asDBA` is `True` if you wish to request `SYSDBA` privileges on the Oracle server. This parameter is optional; if omitted, the default value is `False`.

The first form of `dblink_ora_connect()` returns a `TEXT` value.

The signature of the second form of the `dblink_ora_connect()` function is:

```
dblink_ora_connect(foreign_server_name, asDBA)
```

Where:

foreign_server_name specifies the name of a foreign server.

asDBA is `True` if you wish to request `SYSDBA` privileges on the Oracle server. This parameter is optional; if omitted, the default value is `FALSE`.

The second form of the `dblink_ora_connect()` function allows you to use the connection properties of a pre-defined foreign server when establishing a connection to the server.

Before invoking the second form of the `dblink_ora_connect()` function, use the `CREATE SERVER` command to store the connection properties for the link to a system table. When you call the `dblink_ora_connect()` function, substitute the server name specified in the `CREATE SERVER` command for the name of the link.

The second form of `dblink_ora_connect()` returns a `TEXT` value.

12.1.2 **dblink_ora_status()**

The `dblink_ora_status()` function returns the database connection status. The signature is:

```
dblink_ora_status(conn_name)
```

Where:

conn_name specifies the name of the link.

If the specified connection is active, the function returns a `TEXT` value of `OK`.

12.1.3 **dblink_ora_disconnect()**

The `dblink_ora_disconnect()` function closes a database connection. The signature is:

```
dblink_ora_disconnect(conn_name)
```

Where:

conn_name specifies the name of the link.

The function returns a `TEXT` value.

12.1.4 `dblink_ora_record()`

The `dblink_ora_record()` function retrieves information from a database. The signature is:

```
dblink_ora_record(conn_name, query_text)
```

Where:

conn_name specifies the name of the link.

query_text specifies the text of the SQL `SELECT` statement that will be invoked on the Oracle server.

The function returns a `SETOF` record.

12.1.5 `dblink_ora_call()`

The `dblink_ora_call()` function executes a non-`SELECT` statement on an Oracle database and returns a result set. The signature is:

```
dblink_ora_call(conn_name, command, iterations)
```

Where:

conn_name specifies the name of the link.

command specifies the text of the SQL statement that will be invoked on the Oracle server.

iterations specifies the number of times the statement is executed.

The function returns a `SETOF` record.

12.1.6 `dblink_ora_exec()`

The `dblink_ora_exec()` procedure executes a DML or DDL statement in the remote database. The signature is:

```
dblink_ora_exec(conn_name, command)
```

Where:

conn_name specifies the name of the link.

command specifies the text of the INSERT, UPDATE, or DELETE SQL statement that will be invoked on the Oracle server.

The function returns a VOID.

12.1.7 dblink_ora_copy()

The dblink_ora_copy() function copies an Oracle table to an EnterpriseDB table. The dblink_ora_copy() function returns a BIGINT value that represents the number of rows copied. The signature is:

```
dblink_ora_copy(conn_name, command, schema_name,
table_name, truncate, count)
```

Where:

conn_name specifies the name of the link.

command specifies the text of the SQL SELECT statement that will be invoked on the Oracle server.

schema_name specifies the name of the target schema.

table_name specifies the name of the targettable.

truncate specifies if the server should TRUNCATE the table prior to copying; specify TRUE to indicate that the server should TRUNCATE the table. *truncate* is optional; if omitted, the value is FALSE.

count instructs the server to report status information every *n* record, where *n* is the number specified. During the execution of the function, Advanced Server raises a notice of severity INFO with each iteration of the count. For example, if FeedbackCount is 10, dblink_ora_copy() raises a notice every 10 records. *count* is optional; if omitted, the value is 0.

12.2 Calling `dblink_ora` Functions

The following command establishes a connection using the `dblink_ora_connect()` function:

```
SELECT dblink_ora_connect('acctg', 'localhost', 'xe', 'hr',
  'pwd', 1521);
```

The example connects to a service named `xe` running on port 1521 (on the `localhost`) with a user name of `hr` and a password of `pwd`. You can use the connection name `acctg` to refer to this connection when calling other `dblink_ora` functions.

The following command uses the `dblink_ora_copy()` function over a connection named `edb_conn` to copy the `empid` and `deptno` columns from a table (on an Oracle server) named `ora_acctg` to a table located in the `public` schema on an instance of Advanced Server named `as_acctg`. The `TRUNCATE` option is enforced, and a feedback count of 3 is specified:

```
edb=# SELECT dblink_ora_copy('edb_conn','select empid,
deptno FROM ora_acctg', 'public', 'as_acctg', true, 3);

INFO: Row: 0
INFO: Row: 3
INFO: Row: 6
INFO: Row: 9
INFO: Row: 12

dblink_ora_copy
-----
12

(1 row)
```

The following `SELECT` statement uses `dblink_ora_record()` function and the `acctg` connection to retrieve information from the Oracle server:

```
SELECT * FROM dblink_ora_record( 'acctg', 'SELECT
first_name from employees') AS t1(id VARCHAR);
```

The command retrieves a list that includes all of the entries in the `first_name` column of the `employees` table.

13 System Catalog Tables

The system catalog tables contain definitions of database objects that are available to Advanced Server; the layout of the system tables is subject to change. If you are writing an application that depends on information stored in the system tables, it would be prudent to use an existing catalog view, or create a catalog view to isolate the application from changes to the system table.

For detailed information about the system catalog tables, please see the Database Compatibility for Oracle® Developer's Reference Guide, available at:

<https://www.enterprisedb.com/resources/product-documentation>

14 Acknowledgements

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